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Continuous cardiotocography (CTG) as a form of electronic fetal monitoring (EFM) for fetal assessment during labour (Review)

Alfirevic Z, Gyte GML, Cuthbert A, Devane D

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[Intervention Review]

Continuous cardiotocography (CTG) as a form of electronic fetal monitoring (EFM) for fetal assessment during labour

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ABSTRACT

Background

Cardiotocography (CTG) records changes in the fetal heart rate and their temporal relationship to uterine contractions. The aim is to identify babies who may be short of oxygen (hypoxic) to guide additional assessments of fetal wellbeing, or determine if the baby needs to be delivered by caesarean section or instrumental vaginal birth. This is an update of a review previously published in 2013, 2006 and 2001.

Objectives

To evaluate the effectiveness and safety of continuous cardiotocography when used as a method to monitor fetal wellbeing during labour.

Search methods

We searched the Cochrane Pregnancy and Childbirth Group Trials Register (30 November 2016) and reference lists of retrieved studies.

Selection criteria

Randomised and quasi-randomised controlled trials involving a comparison of continuous cardiotocography (with and without fetal blood sampling) with no fetal monitoring, intermittent auscultation intermittent cardiotocography.

Data collection and analysis

Two review authors independently assessed study eligibility, quality and extracted data from included studies. Data were checked for accuracy.

Main results

We included 13 trials involving over 37,000 women. No new studies were included in this update.

One trial (4044 women) compared continuous CTG with intermittent CTG, all other trials compared continuous CTG with intermittent auscultation. No data were found comparing no fetal monitoring with continuous CTG. Overall, methodological quality was mixed. All included studies were at high risk of performance bias, unclear or high risk of detection bias, and unclear risk of reporting bias. Only two trials were assessed at high methodological quality.

Compared with intermittent auscultation, continuous cardiotocography showed no significant improvement in overall perinatal death rate (risk ratio (RR) 0.86, 95% confidence interval (CI) 0.59 to 1.23, N = 33,513, 11 trials, low quality evidence), but was associated with halving neonatal seizure rates (RR 0.50, 95% CI 0.31 to 0.80, N = 32,386, 9 trials, moderate quality evidence). There was no difference in cerebral palsy rates (RR 1.75, 95% CI 0.84 to 3.63, N = 13,252, 2 trials, low quality evidence). There was an increase in caesarean sections associated with continuous CTG (RR 1.63, 95% CI 1.29 to 2.07, N = 18,861, 11 trials, low quality evidence). Women were also more likely to have instrumental vaginal births (RR 1.15, 95% CI 1.01 to 1.33, N = 18,615, 10 trials, low quality evidence). There was no difference in the incidence of cord blood acidosis (RR 0.92, 95% CI 0.27 to 3.11, N = 2494, 2 trials, very low quality evidence) or use of any pharmacological analgesia (RR 0.98, 95% CI 0.88 to 1.09, N = 1677, 3 trials, low quality evidence).

Compared with intermittent CTG, continuous CTG made no difference to caesarean section rates (RR 1.29, 95% CI 0.84 to 1.97, N = 4044, 1 trial) or instrumental births (RR 1.16, 95% CI 0.92 to 1.46, N = 4044, 1 trial). Less cord blood acidosis was observed in women who had intermittent CTG, however, this result could have been due to chance (RR 1.43, 95% CI 0.95 to 2.14, N = 4044, 1 trial).

Data for low risk, high risk, preterm pregnancy and high-quality trials subgroups were consistent with overall results. Access to fetal blood sampling did not appear to influence differences in neonatal seizures or other outcomes.

Evidence was assessed using GRADE. Most outcomes were graded as low quality evidence (rates of perinatal death, cerebral palsy, caesarean section, instrumental vaginal births, and any pharmacological analgesia), and downgraded for limitations in design, inconsistency and imprecision of results. The remaining outcomes were downgraded to moderate quality (neonatal seizures) and very low quality (cord blood acidosis) due to similar concerns over limitations in design, inconsistency and imprecision.

Authors' conclusions

CTG during labour is associated with reduced rates of neonatal seizures, but no clear differences in cerebral palsy, infant mortality or other standard measures of neonatal wellbeing. However, continuous CTG was associated with an increase in caesarean sections and instrumental vaginal births. The challenge is how best to convey these results to women to enable them to make an informed decision without compromising the normality of labour.

The question remains as to whether future randomised trials should measure efficacy (the intrinsic value of continuous CTG in trying to prevent adverse neonatal outcomes under optimal clinical conditions) or effectiveness (the effect of this technique in routine clinical practice).

Along with the need for further investigations into long-term effects of operative births for women and babies, much remains to be learned about the causation and possible links between antenatal or intrapartum events, neonatal seizures and long-term neurodevelopmental outcomes, whilst considering changes in clinical practice over the intervening years (one-to-one-support during labour, caesarean section rates). The large number of babies randomised to the trials in this review have now reached adulthood and could potentially provide a unique opportunity to clarify if a reduction in neonatal seizures is something inconsequential that should not greatly influence women's and clinicians' choices, or if seizure reduction leads to long-term benefits for babies. Defining meaningful neurological and behavioural outcomes that could be measured in large cohorts of young adults poses huge challenges. However, it is important to collect data from these women and babies while medical records still exist, where possible describe women's mobility and positions during labour and birth, and clarify if these might impact on outcomes. Research should also address the possible contribution of the supine position to adverse outcomes for babies, and assess whether the use of mobility and positions can further reduce the low incidence of neonatal seizures and improve psychological outcomes for women.

PLAIN LANGUAGE SUMMARY

Continuous cardiotocography (CTG) as a form of electronic fetal monitoring (EFM) for fetal assessment during labour

What is the issue?

Is continuous cardiotocography (CTG) to electronically monitor babies' heartbeats and wellbeing during labour better at identifying problems than listening intermittently?

Why is this important?

Monitoring babies' heartbeats is used to check wellbeing during labour. Listening and recording the baby's heartbeat aims to identify babies who are becoming short of oxygen and may benefit from an early delivery by caesarean section or instrumental vaginal birth.

A baby's heartbeat can be monitored intermittently using a special trumpet-shaped device, or hand-held Doppler device. The heartbeat can also be checked continuously using a CTG machine. Continuous CTG produces a paper recording of the baby's heart rate and the mother's labour contractions. Although continuous CTG provides a written record, mothers cannot move freely during labour, change positions easily, or use a birthing pool to help with comfort and control during labour. It also means that some resources tend to be focused on the need to constantly interpret the CTG and not on the needs of a woman in labour.

What evidence did we find?

We searched for evidence on 30 November 2016, but found no new studies for this update. We included 12 trials that compared continuous CTG monitoring with intermittent listening, and one trial compared continuous CTG with intermittent CTG. Together, the trials involved over 37,000 women. No trial compared continuous CTG with no monitoring. Most studies were undertaken before 1994, and apart from two, were not high quality. The review was dominated by one large, well-conducted trial from 1985 which involved almost 13,000 women who received one-to-one care throughout labour. The mothers' membranes were ruptured artificially as early as possible and about a quarter received oxytocin to stimulate contractions.

Overall, there was no difference in numbers of babies who died during or shortly after labour (about one in 300) (low quality evidence). Fits in babies were rare (about one in 500 births) (moderate quality evidence), but occurred less often when continuous CTG was used to monitor the baby's heart rate. There was no difference in the rate of cerebral palsy (low quality evidence); however, other possible long-term effects have not been fully assessed and need further study. Continuous monitoring was associated with significantly more deliveries by caesarean section (low quality evidence) and instrumental vaginal births (low quality evidence). Although both procedures carry risks for mothers, these were not assessed in the included studies.

There was no difference in numbers of cord blood acidosis (very low quality evidence), or women using any drugs for pain relief (low quality evidence) between groups.

Compared with intermittent CTG, continuous CTG made no difference to how many women had caesarean sections or instrumental births. There was less cord blood acidosis in women who had intermittent CTG but this result could have been due to chance.

What does this mean?

Most studies were undertaken many years ago and showed benefits and problems with both methods of monitoring the baby’s wellbeing in labour. Continuous CTG was associated with fewer fits for babies although there was no difference in cerebral palsy; both were rare events. However, continuous CTG was also associated with increased numbers of caesarean sections and instrumental births, both of which carry risks for mothers. Continuous CTG also makes moving and changing positions difficult in labour and women are unable to use a birthing pool. This can impact on women’s coping strategies. Women and their doctors need to discuss the woman’s individual needs and wishes about monitoring the baby’s wellbeing in labour.

Future research should focus on events that happen in pregnancy and labour that could be the cause of long term problems for the baby.

SUMMARY OF FINDINGS

Summary of findings for the main comparison. Continuous CTG versus intermittent auscultation for fetal assessment during labour

Continuous CTG versus intermittent auscultation for fetal assessment during labour

Patient or population: Pregnant women undergoing fetal assessment during labour
Settings: Australia, Denmark, Greece, Ireland, Pakistan, United Kingdom and United States
Intervention: Continuous CTG versus intermittent auscultation

Outcomes	Illustrative comparative risks* (95% CI)		Relative effect (95% CI)	No of participants (studies)	Quality of the evidence (GRADE)	Comments
	Assumed risk	Corresponding risk				
	Control	Continuous CTG versus intermittent auscultation				
Perinatal mortality	Study population		RR 0.86 (0.59 to 1.24)	33,513 (11 studies)	⊕⊕⊝⊝ **low**[1,2]	
	3 per 1000	3 per 1000 (2 to 4)				
	Moderate					
	4 per 1000	3 per 1000 (2 to 5)				
Neonatal seizures	Study population		RR 0.5 (0.31 to 0.8)	32,386 (9 studies)	⊕⊕⊕⊝ **moderate**[1]	
	3 per 1000	1 per 1000 (1 to 2)				
	Moderate					
	4 per 1000	2 per 1000 (1 to 3)				
Cerebral palsy	Study population		RR 1.75 (0.84 to 3.63)	13,252 (2 studies)	⊕⊕⊝⊝ **low**[1,2]	
	3 per 1000	4 per 1000 (2 to 9)				
	Moderate					

	39 per 1000	**68 per 1000** (33 to 142)			
Caesarean section	**Study population**		**RR 1.63** (1.29 to 2.07)	18,861 (11 studies)	⊕⊕⊖⊖ **low**[1,3]
	36 per 1000	**59 per 1000** (47 to 75)			
	Moderate				
	66 per 1000	**108 per 1000** (85 to 137)			
Instrumental vaginal birth	**Study population**		**RR 1.15** (1.01 to 1.33)	18,615 (10 studies)	⊕⊕⊖⊖ **low**[1,3]
	102 per 1000	**118 per 1000** (103 to 136)			
	Moderate				
	222 per 1000	**255 per 1000** (224 to 295)			
Cord blood acidosis	**Study population**		**RR 0.92** (0.27 to 3.11)	2494 (2 studies)	⊕⊖⊖⊖ **very low**[2,4,5]
	24 per 1000	**22 per 1000** (6 to 74)			
	Moderate				
	24 per 1000	**22 per 1000** (6 to 75)			
Any pharmacological analgesia	**Study population**		**RR 0.98** (0.88 to 1.09)	1677 (3 studies)	⊕⊕⊖⊖ **low**[1,6]
	754 per 1000	**739 per 1000** (663 to 822)			
	Moderate				
	805 per 1000	**789 per 1000** (708 to 877)			

*The basis for the **assumed risk** (e.g. the median control group risk across studies) is provided in footnotes. The **corresponding risk** (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI).
CI: Confidence interval; **RR:** Risk ratio;

GRADE Working Group grades of evidence
High quality: Further research is very unlikely to change our confidence in the estimate of effect.
Moderate quality: Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate.
Low quality: Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate.
Very low quality: We are very uncertain about the estimate.

[1] Limitations in design: Most studies contributing data had design limitations (< 40% weight).
[2] Wide confidence interval crossing the line of no effect.
[3] Statistical heterogeneity (I^2 = 60%)
[4] Limitations in design: One study with serious design limitations contributing 56.4% weight.
[5] Statistical heterogeneity (I^2 = 77%)
[6] Statistical heterogeneity (I^2 = 72%)

BACKGROUND

The baby's heart beat was first thought to be heard in utero in the middle of the seventeenth or eighteenth century (Grant 1989a; Gibb 1992), but it was not until the early nineteenth century that de Kergeradee suggested that listening to the baby's heartbeat might be clinically useful (Grant 1989a). De Kergeradee proposed that listening to the baby's heartbeat could be used to diagnose fetal life and multiple pregnancies, and wondered if it would be possible to assess fetal compromise from variations in the fetal heart rate (FHR). Since then, various methods of listening to the fetal heart have been developed and introduced into maternity care (Table 1), each with the aim of improving outcomes for babies and reducing the heartache for mothers and families when a baby dies or sustains long-term disability. Today, monitoring the fetal heart during labour, by one method or another, appears to have become a routine part of care during labour, although access to such care varies across the world.

Description of the condition

The incidence of neonatal morbidity and mortality varies around the world, although direct comparisons may be difficult because of varying definitions and classifications. Nevertheless, large differences are reported between high-income countries with average neonatal mortality rates (NMR) of four per 1000 live births) and low- or middle-income countries with average NMRs of 33 per 1000 births) (Lawn 2005). Although most perinatal morbidity and mortality may not be prevented by improved fetal monitoring in labour (Nelson 1996), failure in identifying abnormal FHR patterns and lack of appropriate actions are considered to be significant contributing factors (MCHRC 1997; MCHRC 1998; MCHRC 1999).

Description of the intervention

The baby's heart rate can be monitored either intermittently (at regular intervals during labour) or continuously (recording the baby's heart rate throughout labour, stopping only briefly, such as for visits to the toilet) as follows.

Fetal stethoscope (Pinard) and hand-held Doppler

Intermittent monitoring can be undertaken either by listening to the baby's heart rate using a fetal stethoscope (Pinard), or with a hand-held Doppler ultrasound device, and by palpating the mother's uterine contractions by hand. This is known as intermittent auscultation.

Cardiotocograph (CTG)

The baby's heart rate and the mother's uterine contractions can be recorded electronically on a paper trace known as a cardiotocograph. This is done using a Doppler ultrasound transducer to monitor the baby's heart rate and a pressure transducer to monitor uterine contractions, both of which are linked to a recording device. This is known as external cardiotocography (external CTG) and is usually undertaken continuously in labour, although it is sometimes used intermittently (intermittent CTG). In most units, external CTG requires the mother to wear a belt across her abdomen during monitoring, which restricts her mobility. An alternative means of monitoring the baby's heart rate with the CTG machine is to attach an electrode directly to the baby's presenting part, usually the head. This form of continuous monitoring is known as internal CTG and requires a ruptured amniotic sac (either spontaneously or artificially) and a scalp electrode (clip) attached to the baby's head. This also restricts the woman's mobility.

The term electronic fetal monitoring (EFM) is sometimes used synonymously with CTG monitoring, but is considered to be a less precise term because CTG monitoring also includes monitoring the mother's contractions, and other forms of fetal monitoring might also be classed as 'electronic', such as fetal electrocardiograph or fetal pulse oximetry.

Intermittent auscultation was the predominant method of monitoring during labour until CTGs became widely used in the latter part of the twentieth century (Enkin 2000). Although there is a lack of empirical evidence on the optimal frequency of intermittent auscultation, there is a consensus in clinical guidelines that the fetal heart should be auscultated at least every 15 minutes in the first stage of labour and at least every five minutes in the second stage of labour (ACOG 2009; Liston 2007; NICE 2014; RANZCOG 2014) with each auscultation lasting at least 60 seconds (Liston 2007; NICE 2014). It appears that these auscultation protocols were developed initially in the context of clinical trials and were based on common sense rather than research evidence. Compliance with these guidelines, whilst maintaining contemporaneous records, poses a significant challenge for caregivers during labour who usually have multiple tasks to fulfil simultaneously.

Information and interpretation

Both intermittent auscultation and CTG provide information on the baseline heart rate (usually between 110 and 160 beats per minute in the term fetus), accelerations (transient increases in the FHR) and decelerations (transient decreases in the FHR). Some aspects of labour cause natural alterations in FHR patterns. For example, the baby's sleep FHR pattern differs from the waking FHR pattern. External stimuli, such as uterine contractions and the mother moving, can cause FHR changes, as can administration of opiates to the mother. Some of these changes are subtle and can only be detected by continuous CTG, such as baseline variability and temporal shape of decelerations. Consideration is needed about whether such information improves detection and outcomes for babies who are truly compromised and if there are technology-related disadvantages for those who are not compromised.

Sensitivity and specificity

While specific abnormalities of the FHR pattern on CTG are proposed as being associated with an increased risk of cerebral palsy (Nelson 1996), CTG specificity to predict cerebral palsy is low, with a reported false positive rate as high as 99.8%, even in the presence of multiple late decelerations or decreased variability (Nelson 1996).

FHR pattern recognition, including the relationship between uterine contractions and FHR decelerations, are fundamental to the use of continuous CTG monitoring. Algorithms have been developed to assess and record what is normal, what requires more careful attention, and what is considered abnormal requiring immediate delivery of the baby (NICE 2014). However, CTG traces are often interpreted differently by different caregivers (inter-observer variation) and even by the same caregiver interpreting the same record at different times (intra-observer variation) (Devane 2005). Such variation in interpretation of CTG tracings may result in inappropriate interventions, or false reassurance and lack of

appropriate intervention. Although we were unable to find studies that sought to investigate inter- and intra-observer variation in intermittent auscultation, it would seem reasonable to suggest that intermittent auscultation is not immune to similar problems caused by inter- and intra-observer variation. However, given that the FHR parameter of interest in intermittent auscultation is the baseline FHR, it is likely that inter- and intra-observer variation is less in intermittent auscultation than that found in CTG interpretation where other aspects of FHR patterns including variability and assessment and deceleration classification require interpretation.

Additional tests

Fetal blood sampling is a procedure where a small amount of blood is taken from the baby, usually from the scalp. Performing fetal blood sampling and measuring the parameters of acid-base balance (pH, base excess/deficit, etc) seeks to identify those babies who are truly compromised and need to be born immediately. It is important to establish the value of this test as an adjunct to CTG. This question was addressed in a subgroup analysis in this review.

Other methods have been considered as additional tests, but there is little evidence to support their use, for example, vibroacoustic stimulation (East 2013). Several other methods of fetal monitoring have been proposed, either as an adjunct or an alternative to CTG, such as pulse oximetry (Carbonne 1997; East 2007), near-infrared spectroscopy (Mozurkewich 2000), fetal ECG (Neilson 2015), ST segment analysis of the fetal ECG (Luttkus 2004). and fetal stimulation tests (Skupski 2002).

Possible advantages of CTG

- More measurable parameters related to FHR patterns.
- The CTG trace gives a continuous recording of the FHR and uterine activity. This is a physical record, which can be examined at any time in labour, or subsequently, if required. The examples where physical records may be useful include clinical audits, counselling parents if there has been as adverse outcome, and medico-legal situations.

Possible disadvantages of CTG

- The complexity of FHR patterns makes standardisation difficult.
- CTG prevents mobility and restricts the use of massage, different positions, or immersion in water used to improve comfort, control and coping strategies during labour.
- Shifting staff focus and resources away from the mother may encourage a belief that all perinatal mortality and neurological injury can be prevented.

Specific situations that may influence the effectiveness or otherwise of CTG

1. Continuous CTG is generally recommended for women who are regarded as being at increased risk of perinatal morbidity and mortality (Liston 2007; NICE 2014; RANZCOG 2014). This review addressed the issue of differential effects of CTG in terms of risk status.
2. Induction of labour is primarily performed where it is anticipated that outcomes for mothers and infants would be improved were labour induced. Given that induction of labour includes iatrogenic stimulation of uterine activity, which puts the baby at greater risk, we determined to perform a subgroup analysis by induction of labour (NICE 2008).
3. Preterm birth is associated with an increased risk of mortality and neurological morbidity, and these babies might benefit from being monitored more intensively. Further, there is debate about what is normal for the different parameters of the CTG for preterm infants at varying gestational ages. Therefore, we performed a preterm subgroup analysis.
4. Twin pregnancies carry a higher perinatal mortality rate than singleton pregnancies (NICE 2011), thus we conducted a subgroup analysis by twin pregnancy.

Women's and professional views

Some studies looking at women's preferences found that the support that women received from staff and labour companions was more important to them than the type of monitoring used (Garcia 1985; Killien 1989). A more recent study of women's views of routine continuous CTG in labour in the UK identified a lack of discussion about the need for and appropriateness of CTG. In addition, women felt that CTG limited their mobility and led to an acceptance of the machine's place as the focus of attention for the woman and her partner (Munro 2004).

In a synthesis of 11 studies on professionals' views of FHR monitoring during labour, Smith 2012 identified that despite an absence of evidence, maternity care professionals perceived the CTG as offering 'proof' of the compromised baby and that this minimises their exposure to criticism and potential litigation. Nevertheless, professionals also recognised that the CTG offered a false sense of security.

How the intervention might work

Although monitoring FHR changes during labour, it is hoped to identify those babies who may be compromised, or potentially compromised, by a shortage of oxygen (fetal hypoxia). If the shortage of oxygen is both prolonged and severe, babies are at risk of being born with a disability (physical, mental or both), or death during labour or shortly thereafter. When alterations in the FHR during labour suggest that the baby is hypoxic, or at risk of hypoxia, additional methods of assessment of fetal wellbeing (e.g. fetal blood sampling) may be used. Sometimes FHR alterations trigger delivery by caesarean section or use of instruments, such as forceps or vacuum extractor, even without recourse to additional diagnostic tests.

Why it is important to do this review

Concerns have been raised about the efficacy and safety of routine use of continuous CTG in labour (Thacker 1995). The apparent contradiction between the widespread use of continuous CTG with claims of its effectiveness in lowering early neonatal mortality and morbidity (Chen 2011) and recommendations to limit its routine use on all women (NICE 2014), indicates that a regular reassessment of this practice is warranted.

Several Cochrane reviews have addressed other methods for assessing the condition of the fetus during labour including fetal electrocardiogram/ECG (Neilson 2015); fetal pulse oximetry (East 2007); near-infrared spectroscopy (Mozurkewich 2000) and vibroacoustic stimulation (East 2013). Also, the comparison of cardiotocography versus intermittent auscultation of fetal heart as

an admission test on arrival to labour ward is assessed elsewhere (Devane 2017).

OBJECTIVES

To evaluate the effectiveness and safety of continuous cardiotocography (CTG) when used as a method to monitor fetal wellbeing during labour.

METHODS

Criteria for considering studies for this review

Types of studies

All randomised trials and quasi-randomised studies comparing continuous CTG during labour, with and without fetal blood sampling, with no fetal monitoring, intermittent auscultation of the fetal heart rate with a Pinard stethoscope or hand-held Doppler ultrasound device, or intermittent CTG. Sensitivity analysis was undertaken for studies graded as low risk of bias based on sequence generation and allocation concealment.

Types of participants

Pregnant women in labour and their babies.

Types of interventions

The main intervention of interest was continuous CTG during labour.

For the purpose of this review, the intervention was defined as an attempt to produce a continuous and simultaneous hard-copy recording of the fetal heart rate and uterine contractions in real time throughout the woman's labour. As a guide, continuous CTG should be discontinued only for short periods (for example, during visits to the toilet) and the CTG should be used for clinical decision making during labour.

Control groups of interest included: no fetal monitoring, intermittent auscultation of the fetal heart rate with a Pinard stethoscope or hand-held Doppler ultrasound device, or intermittent CTG.

Types of outcome measures

Main outcomes

1. Perinatal mortality;
2. seizures in the neonatal period, either apparent clinically or detected by electro-encephalographic recordings;
3. cerebral palsy;
4. caesarean section;
5. instrumental vaginal birth;
6. cord blood acidosis (low pH/low base excess as defined by trialists; where reports included a range of pH values we used cord pH < 7.10 as a cut off for acidosis); and
7. use of all forms of pharmacological analgesia during labour and birth (including epidural but excluding anaesthesia for caesarean section).

Other important outcomes

1. Hypoxic ischaemic encephalopathy (as defined by trialists);
2. neurodevelopmental disability assessed at 12 months of age or more. Neurodevelopmental disability, defined as any one or combination of the following: non-ambulant cerebral palsy, developmental delay, auditory and visual impairment. Development should have been assessed by means of a previously validated tool, such as Bayley Scales of Infant Development (Psychomotor Developmental Index and Mental Developmental Index (Bayley 1993);
3. Apgar less than seven at five minutes;
4. Apgar less than four at five minutes;
5. admission to neonatal special care and/or intensive care unit;
6. fetal blood sampling;
7. damage/infection to baby's head from scalp electrode or fetal blood sampling;
8. caesarean section for abnormal fetal heart rate pattern and fetal acidosis or both;
9. instrumental vaginal birth for abnormal fetal heart rate pattern and fetal acidosis or both;
10. spontaneous vaginal birth not achieved;
11. epidural analgesia;
12. use of non pharmacological methods of coping with labour, e.g. transcutaneous electrical nerve stimulation, hydrotherapy;
13. amniotomy (artificial rupture of membranes);
14. oxytocin during labour;
15. perineal trauma requiring repair (including episiotomy);
16. inability to adopt preferred position during labour;
17. dissatisfaction with labour and perceived loss of control during labour or both;
18. postpartum depression;
19. exclusively breastfeeding at discharge from hospital; and
20. length of stay in neonatal special care and intensive care unit or both.

Search methods for identification of studies

The following section of this review was based on a standard template used by Cochrane Pregnancy and Childbirth.

Electronic searches

We searched Cochrane Pregnancy and Childbirth's Trials Register by contacting their Information Specialist (30 November 2016).

The Register is a database containing over 22,000 reports of controlled trials in the field of pregnancy and childbirth. For full search methods used to populate Pregnancy and Childbirth's Trials Register including the detailed search strategies for CENTRAL, MEDLINE, Embase and CINAHL; the list of handsearched journals and conference proceedings, and the list of journals reviewed via the current awareness service, please follow this link to the editorial information about the Cochrane Pregnancy and Childbirth in the Cochrane Library and select the '***Specialized Register***' section from the options on the left side of the screen.

Briefly, Cochrane Pregnancy and Childbirth's Trials Register is maintained by their Information Specialist and contains trials identified from:

1. monthly searches of the Cochrane Central Register of Controlled Trials (CENTRAL);

2. weekly searches of MEDLINE (Ovid);
3. weekly searches of Embase (Ovid);
4. monthly searches of CINAHL (EBSCO);
5. handsearches of 30 journals and the proceedings of major conferences;
6. weekly current awareness alerts for a further 44 journals plus monthly BioMed Central email alerts.

Search results are screened by two people and the full text of all relevant trial reports identified through the searching activities described above is reviewed. Based on the intervention described, each trial report is assigned a number that corresponds to a specific Pregnancy and Childbirth review topic (or topics), and is then added to the Register. The Information Specialist searches the Register for each review using this topic number rather than keywords. This results in a more specific search set which has been fully accounted for in the relevant review sections (Included studies; Excluded studies; Studies awaiting classification).

[We carried out additional author searching in the Alfirevic 2006 version of this review. We subsequently chose not to repeat these additional searches because they yielded no additional studies.]

Searching other resources

We searched the reference lists of retrieved studies. We did not apply any language or date restrictions.

Data collection and analysis

For methods used in the previous version of this review, see Alfirevic 2013.

For this update, there were no reports identified as a result of the updated search. In future updates, the following methods will be used for assessing the reports that are identified as a result of the updated search.

The following methods section of this review is based on a standard template used by Cochrane Pregnancy and Childbirth.

Selection of studies

Two review authors independently assessed for inclusion all the potential studies identified as a result of the search strategy. We resolved any disagreement through discussion or, if required, we consulted a third review author.

Data extraction and management

We designed a form to extract data. For eligible studies, two review authors extracted the data using the agreed form. We resolved discrepancies through discussion or, if required, we consulted the third review author. Data were entered into Review Manager software (RevMan 2014) and checked for accuracy.

When information regarding any of the above was unclear, we planned to contact authors of the original reports to provide further details.

Assessment of risk of bias in included studies

Two review authors independently assessed risk of bias for each study using the criteria outlined in the *Cochrane Handbook for Systematic Reviews of Interventions* (Higgins 2011). Any disagreement was resolved by discussion or by involving a third review author.

(1) Random sequence generation (checking for possible selection bias)

We described the method used to generate the allocation sequence in sufficient detail to allow an assessment of whether it should produce comparable groups for each included study.

We assessed the method as:

- low risk of bias (any truly random process, e.g. random number table; computer random number generator);
- high risk of bias (any non-random process, e.g. odd or even date of birth; hospital or clinic record number);
- unclear risk of bias.

(2) Allocation concealment (checking for possible selection bias)

We described the method used to conceal allocation to interventions prior to assignment and assessed whether intervention allocation could have been foreseen in advance of, or during recruitment, or changed after assignment for each included study

We assessed the methods as:

- low risk of bias (e.g. telephone or central randomisation; consecutively numbered sealed opaque envelopes);
- high risk of bias (open random allocation; unsealed or non-opaque envelopes, alternation; date of birth);
- unclear risk of bias.

(3.1) Blinding of participants and personnel (checking for possible performance bias)

We described the methods used, if any, to blind study participants and personnel from knowledge of which intervention a participant received for each included study. We considered that studies were at low risk of bias if they were blinded, or if we judged that the lack of blinding unlikely to affect results. We assessed blinding separately for different outcomes or classes of outcomes.

We assessed the methods as:

- low, high or unclear risk of bias for participants;
- low, high or unclear risk of bias for personnel.

(3.2) Blinding of outcome assessment (checking for possible detection bias)

We described for each included study the methods used, if any, to blind outcome assessors from knowledge of which intervention a participant received. We assessed blinding separately for different outcomes or classes of outcomes.

We assessed methods used to blind outcome assessment as:

- low, high or unclear risk of bias.

(4) Incomplete outcome data (checking for possible attrition bias due to the amount, nature and handling of incomplete outcome data)

For each included study, and for each outcome or class of outcomes, we described the completeness of data including attrition and exclusions from the analysis. We stated whether attrition and exclusions were reported and the numbers included in the analysis at each stage (compared with the total randomised participants), reasons for attrition or exclusion where reported, and whether missing data were balanced across groups or related to outcomes. Where sufficient information was reported, or could be supplied by the trial authors, we planned to re-include missing data in the analyses.

We assessed methods as:

- low risk of bias (e.g. no missing outcome data; missing outcome data balanced across groups);
- high risk of bias (e.g. numbers or reasons for missing data imbalanced across groups; 'as treated' analysis done with substantial departure of intervention received from that assigned at randomisation);
- unclear risk of bias.

(5) Selective reporting (checking for reporting bias)

We described how we investigated the possibility of selective outcome reporting bias and what we found for each included study.

We assessed the methods as:

- low risk of bias (where it is clear that all of the study's pre-specified outcomes and all expected outcomes of interest to the review have been reported);
- high risk of bias (where not all the study's pre-specified outcomes have been reported; one or more reported primary outcomes were not pre-specified; outcomes of interest are reported incompletely and so cannot be used; study fails to include results of a key outcome that would have been expected to have been reported);
- unclear risk of bias.

(6) Other bias (checking for bias due to problems not covered by points (1) to (5))

We described any important concerns we had about other possible sources of bias for each included study.

(7) Overall risk of bias

We made explicit judgements about whether studies were at high risk of bias, according to the criteria in the *Handbook* (Higgins 2011). With reference to points (1) to (6), we planned to assess the likely magnitude and direction of the bias and if we considered it was likely to impact on findings. In future updates, we will explore the impact of the level of bias through undertaking sensitivity analyses (see Sensitivity analysis).

Assessment of the quality of the evidence using the GRADE approach

For this update, the quality of the evidence was assessed using the GRADE approach as outlined in the GRADE handbook to assess the quality of the body of evidence relating to the following main outcomes for the main comparison (Continuous CTG versus intermittent auscultation for fetal assessment during labour).

1. Perinatal mortality;
2. seizures in the neonatal period, either apparent clinically or detected by electro-encephalographic recordings;
3. cerebral palsy;
4. caesarean section;
5. instrumental vaginal birth;
6. cord blood acidosis (low pH/low base excess as defined by trialists; where report included a range of pH values we have used cord pH < 7.10 as a cut off for acidosis); and
7. use of all forms of pharmacological analgesia during labour and birth (including epidural but excluding anaesthesia for caesarean section).

GRADEpro Guideline Development Tool was used to import data from Review Manager 5.3 (RevMan 2014) to create a 'Summary of findings' table. A summary of the intervention effect and a measure of quality for each of the outcomes was produced using the GRADE approach. The GRADE approach uses five considerations (study limitations, consistency of effect, imprecision, indirectness and publication bias) to assess the quality of the body of evidence for each outcome. The evidence can be downgraded from high quality by one level for serious (or by two levels for very serious) limitations, depending on assessments for risk of bias, indirectness of evidence, serious inconsistency, imprecision of effect estimates or potential publication bias.

Measures of treatment effect

Dichotomous data

For dichotomous data, we presented results as summary risk ratio with 95% confidence intervals.

Continuous data

We used the mean difference if outcomes were measured in the same way between trials. We used the standardised mean difference to combine trials that measured the same outcome, but used different methods.

Unit of analysis issues

Cluster-randomised trials

No cluster-randomised trials were identified for inclusion in this review. In future updates, we will include cluster-randomised trials in the analyses along with individually randomised trials. We will adjust their sample sizes using the methods described in the *Handbook* (Section 16.3.4) using an estimate of the intracluster correlation co-efficient (ICC) derived from the trial (if possible), from a similar trial or from a study of a similar population. If we use ICCs from other sources, we will report this and conduct sensitivity analyses to investigate the effect of variation in the ICC. If we identify both cluster-randomised trials and individually-randomised trials, we plan to synthesise the relevant information. We will consider it reasonable to combine the results from both if there is little heterogeneity between the study designs and the interaction between the effect of intervention and the choice of randomisation unit is considered to be unlikely.

We will also acknowledge heterogeneity in the randomisation unit and perform a sensitivity analysis to investigate the effects of the randomisation unit.

Cross-over trials

Cross-over trials are not a suitable trial design for this type of intervention.

Other unit of analysis issues

Multiple pregnancies

Outcomes for babies from the same pregnancy (twins or higher multiples) are not independent. For some outcomes (e.g. preterm birth) outcomes for babies from the same pregnancy are likely to be the same, or very highly correlated. For other outcomes there would be a lower correlation (e.g. fetal death or infant anomaly). We were unable to include any separate data for multiple pregnancies in the analysis, so did not make any adjustments. In future updates, to take account of the non-independence of outcomes for babies from multiple pregnancies, we will treat each multiple pregnancy as a cluster and analyse data using methods described for cluster-randomised trials. We will seek ICCs for outcomes for twins and higher multiples from trials (if available) from similar trials or from observational studies. Where published ICCs are not available, we will consult with experts in the field to estimate ICCs, and conduct sensitivity analysis using a range of ICC values.

Trials with more than two arms

We included one trial (Denver 1979) which had three treatment arms. For analysis of the main comparison and subgroups, we pooled results of the treatment arms (continuous CTG with fetal blood sampling (FBS), and continuous CTG without FBS) using the methods set out in the *Handbook* (Higgins 2011) to avoid double-counting. In the subgroup analysis 6 (access to fetal blood sampling (FBS) during labour versus no access to FBS during labour), we reported the two trial arms separately and divided the control group in the analysis using the methods set out in the *Handbook* (Higgins 2011) to avoid double-counting.

Dealing with missing data

Levels of attrition were noted for included studies. In future updates, if more eligible studies are included, the impact of including studies with high levels of missing data on the overall assessment of treatment effect will be explored in sensitivity analyses.

For all outcomes, analyses were carried out, as far as possible, on an intention-to-treat basis. That is, we attempted to include all participants randomised to each group in the analyses. The denominator for each outcome in each trial was the number of participants randomised minus any participants whose outcomes were known to be missing.

Assessment of heterogeneity

We assessed statistical heterogeneity in meta-analyses using the Tau^2, I^2 and Chi^2 statistics. We regarded heterogeneity as substantial if I^2 was greater than 30% and either Tau^2 was greater than zero, or there was a low P value (< 0.10) in the Chi^2 test for heterogeneity. If we identified substantial heterogeneity (> 30%), we planned to explore it by pre-specified subgroup analysis.

Assessment of reporting biases

Where there were 10 or more studies in the meta-analysis we investigated reporting biases (such as publication bias) using funnel plots. We assessed funnel plot asymmetry visually. If asymmetry was suggested by a visual assessment, we performed exploratory analyses to investigate.

Data synthesis

We carried out statistical analysis using Review Manager software (RevMan 2014). We used fixed-effect meta-analysis for combining data where it was reasonable to assume that studies were estimating the same underlying treatment effect: that is, where trials were examining the same intervention, and the trials' populations and methods were judged to be sufficiently similar.

If there was clinical heterogeneity sufficient to expect that the underlying treatment effects differed among trials, or if substantial statistical heterogeneity was detected, we used random-effects meta-analysis to produce an overall summary if an average treatment effect across trials was considered clinically meaningful. The random-effects summary was to be treated as the average range of possible treatment effects and we planned to discuss the clinical implications of treatment effects differing among trials. If the average treatment effect was not clinically meaningful, we did not combine trials. If we used random-effects analyses, the results were presented as the average treatment effect with 95% confidence intervals, and the estimates of Tau^2 and I^2.

Subgroup analysis and investigation of heterogeneity

If we identified substantial heterogeneity, it was investigated using subgroup and sensitivity analyses. We considered whether an overall summary was meaningful, and if it was, we used random-effects analysis to produce the effect.

We carried out the following subgroup analyses:

1. high risk for perinatal mortality and morbidity (as defined by trialists) versus low risk (absence of identifiable risk factors associated with increased in perinatal mortality and morbidity as defined by trialists);
2. spontaneous onset of labour versus induction of labour;
3. preterm (less than 37 + 0 weeks) versus term (> 37 + 0 weeks);
4. singleton pregnancy versus twin pregnancy;
5. access to fetal blood sampling (FBS) during labour versus no access to FBS during labour;
6. primiparous versus multiparous.

Subgroup analysis was restricted to the review's main outcomes.

We assessed subgroup differences by interaction tests available within RevMan (RevMan 2014). We reported the results of subgroup analyses quoting the Chi^2 statistic and P value, and the interaction test I^2 value.

Sensitivity analysis

We carried out sensitivity analyses to explore the effect of trial quality assessed by concealment of allocation, high attrition rates, or both, with poor quality studies being excluded from the analyses to assess if this made any difference to the overall result. We also explored the effect of high and unclear quality studies on the

analysis by performing interaction tests. This is documented in Comparison 8 in Effects of interventions.

RESULTS

Description of studies

Results of the search

Our search strategy identified 383 citations corresponding to 17 studies for potential inclusion. Of those, 13 studies that involved a total of 37,715 women were included (Athens 1993; Copenhagen 1985; Dallas 1986; Denver 1976; Denver 1979; Dublin 1985; Lund 1994; Melbourne 1976; Melbourne 1981; New Delhi 2006; Pakistan 1989; Seattle 1987; Sheffield 1978) and four were excluded (Harare 1994; Ioannina 2001; Manchester 1982; North America 2000). In the 2016 update, Greece 2012 was also excluded. The updated search in November 2016 did not retrieve any further reports.

Included studies

Of the 13 included studies, two were quasi-RCTs (Copenhagen 1985; Dallas 1986), two used block randomisation (Dublin 1985; Lund 1994), and six used individual randomisation (Athens 1993; Denver 1976; Denver 1979; Melbourne 1976; Melbourne 1981; Pakistan 1989). Three studies (New Delhi 2006; Seattle 1987; Sheffield 1978) did not provide details of randomisation processes.

Of the 13 included studies, 12 (N = 33,681 women) compared continuous CTG with intermittent auscultation (Athens 1993; Copenhagen 1985; Dallas 1986; Denver 1976; Denver 1979; Dublin 1985; Melbourne 1976; Melbourne 1981; New Delhi 2006; Pakistan 1989; Seattle 1987; Sheffield 1978). Five studies compared continuous CTG plus fetal blood sampling versus intermittent auscultation (Copenhagen 1985; Dublin 1985; Melbourne 1976; Pakistan 1989; Seattle 1987) and six compared continuous CTG without fetal blood sampling versus intermittent auscultation (Athens 1993; Dallas 1986; Denver 1976; Melbourne 1981; New Delhi 2006; Sheffield 1978). One study had three groups comparing continuous CTG with and without fetal blood sampling versus intermittent auscultation (Denver 1979). One study compared continuous CTG with fetal blood sampling versus intermittent CTG with fetal blood sampling (Lund 1994).

Participants were assessed as being at low risk of complications in four studies (Dallas 1986; Lund 1994; Melbourne 1981; Sheffield 1978) and outcome data for women at low risk were available for one outcome, neonatal seizures, from another study (Dublin 1985). Participants were assessed as being at high risk of complications in six studies (Denver 1976; Denver 1979; Melbourne 1976; New Delhi 2006; Pakistan 1989; Seattle 1987) including one study that specifically included women in preterm labour (28 to 32 weeks) and assessed outcomes for babies below 1750 g birthweight (Seattle 1987). The data for neonatal seizures in women at high risk of complications were available from one study (Dublin 1985). Participants were assessed as mixed risk (mixture of women at high risk and low risk of complications) in three studies (Athens 1993; Copenhagen 1985; Dublin 1985).

Five studies had overall caesarean section rates below 10% (Athens 1993; Copenhagen 1985; Dublin 1985; Melbourne 1981; Sheffield 1978). The highest overall caesarean section rates were reported in Pakistan 1989 (23.5%) and New Delhi 2006 (28%).

Table 2 shows additional descriptive information for all included studies.

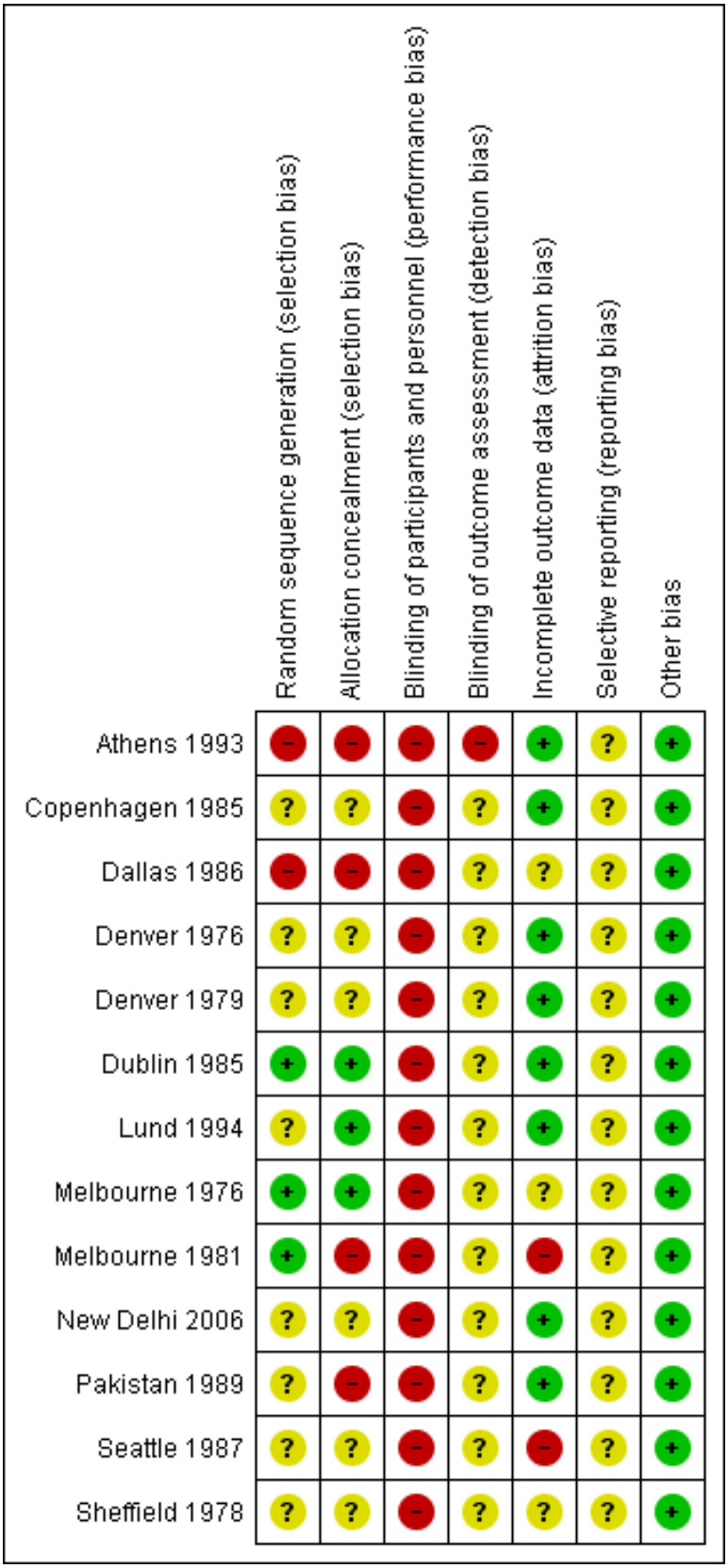
Excluded studies

We excluded five studies (Characteristics of excluded studies). Of these, three studies (Greece 2012; Harare 1994; North America 2000) were excluded because the interventions compared did not meet our inclusion criteria; one study was non-randomised (Ioannina 2001); and one study did not report any data for the control group (Manchester 1982).

Risk of bias in included studies

See Figure 1 for a summary of risk of bias assessments.

Figure 1. Methodological quality summary: review authors' judgements about each methodological quality item for each included study



Allocation

Allocation concealment was assessed as low risk of bias in three trials (Dublin 1985; Lund 1994; Melbourne 1976); unclear in six trials (Copenhagen 1985; Denver 1976; Denver 1979; New Delhi 2006; Seattle 1987; Sheffield 1978); and high risk in four trials (Athens 1993; Dallas 1986; Melbourne 1981; Pakistan 1989).

Blinding

Blinding of participants and personnel was assessed as high risk of bias in all 13 studies. Blinding of outcome assessment was assessed as unclear in all but one study where it was assessed as high risk of bias (Athens 1993).

Incomplete outcome data

Attrition bias was graded as low risk in eight trials (Athens 1993; Copenhagen 1985; Denver 1976; Denver 1979; Dublin 1985; Lund 1994; New Delhi 2006; Pakistan 1989); unclear in three trials (Dallas 1986; Melbourne 1976; ; Sheffield 1978); and high risk in two trials (Melbourne 1981; Seattle 1987).

Selective reporting

This was assessed as 'unclear risk of bias' in all 13 studies as we did not have access to any of the trial protocols.

Other potential sources of bias

All 13 studies were considered at low risk for other potential sources of bias.

Effects of interventions

See: **Summary of findings for the main comparison** Continuous CTG versus intermittent auscultation for fetal assessment during labour

Continuous cardiotocography (CTG) versus intermittent auscultation (IA) (Comparisons 1 to 8)

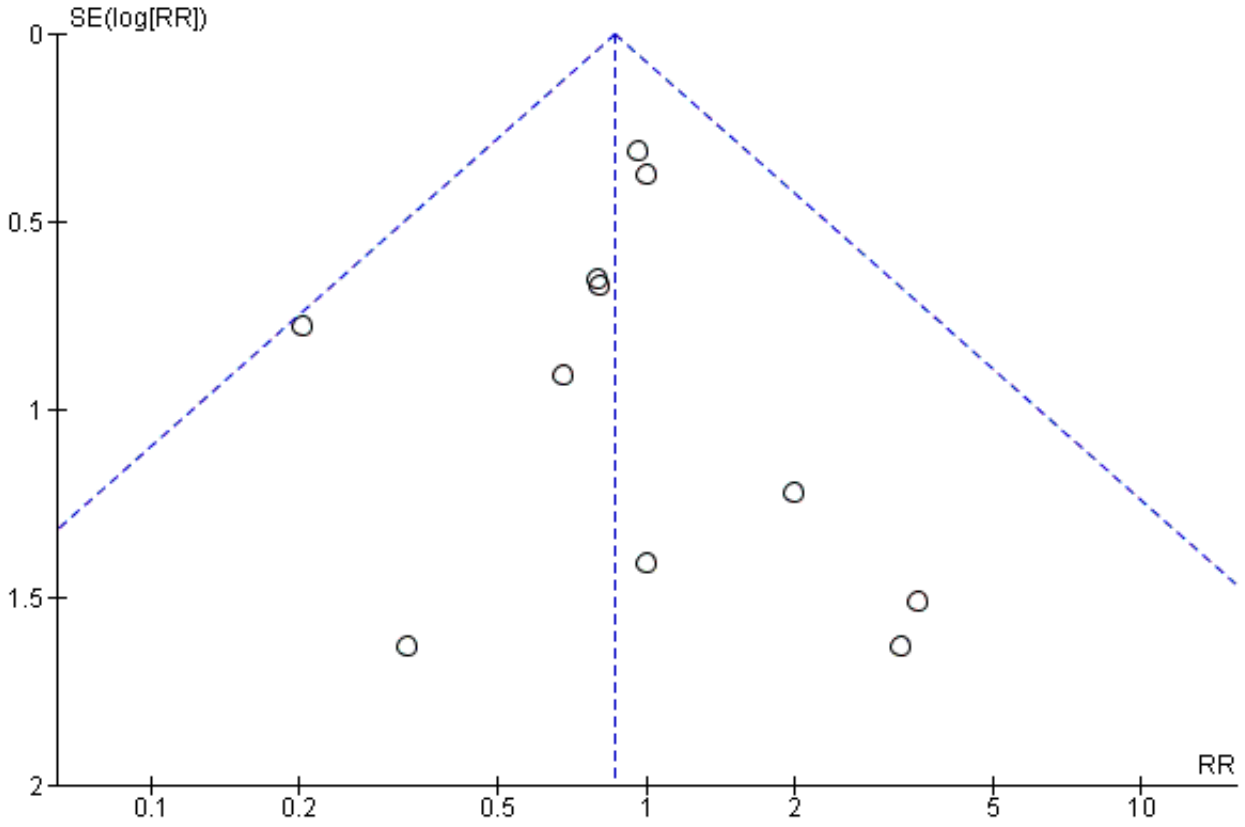
A total of 13 randomised trials were included in this comparison with over 33,000 women participating (Athens 1993; Copenhagen 1985; Dallas 1986; Denver 1976; Denver 1979; Dublin 1985; Melbourne 1976; Melbourne 1981; New Delhi 2006; Pakistan 1989; Seattle 1987; Sheffield 1978). Denver 1979 was a three-arm trial comparing continuous CTG alone, versus continuous CTG plus fetal bood sampling (FBS) versus intermittent auscultation.

Main outcomes

For the infant

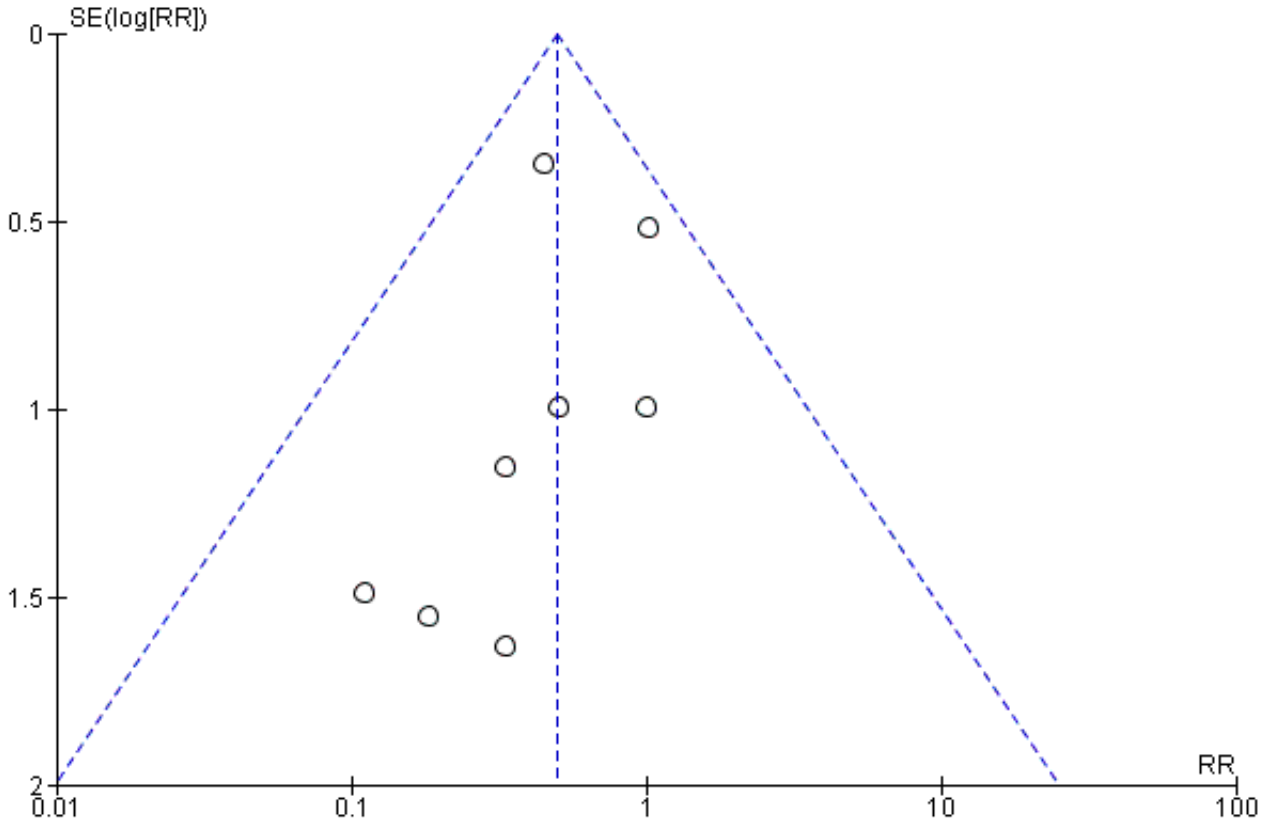
There was no significant difference in perinatal mortality between the groups. Risk ratio (RR) was 0.86 with, 95% confidence intervals (CIs) ranging from 0.59 to 1.24, N = 33,513, 11 trials, (Analysis 1.1). The funnel plot analysis indicated no missing studies (Figure 2). The quality of the evidence for this outcome was assessed as moderate (Summary of findings for the main comparison).

Figure 2. Funnel plot of comparison: 1 Continuous CTG versus intermittent auscultation, outcome: 1.1 Perinatal mortality (main outcome)



The use of continuous CTG monitoring in labour halved the risk of neonatal seizures (RR 0.50, 95% CI 0.31 to 0.80, N = 32,386, 9 trials, Analysis 1.2). The funnel plot indicated no missing studies (Figure 3) and the quality of the evidence was assessed as moderate (Summary of findings for the main comparison). This reduction was consistent across the trials and subgroups, although the incidence of neonatal seizures varied considerably among trials. In the two largest trials of 14,618 women (Dallas 1986) and 12,964 women (Dublin 1985), the incidence of neonatal seizures in the intermittent auscultation groups was 0.04% and 0.4% respectively (Analysis 1.2). In the two high-quality trials reporting data for this outcome (Dublin 1985; Melbourne 1976), the risk of neonatal seizures was RR 0.40, 95% CI 0.21 to 0.77 (Analysis 8.2).

Figure 3. Funnel plot of comparison: 1 Continuous CTG versus intermittent auscultation, outcome: 1.2 Neonatal seizures (main outcome)



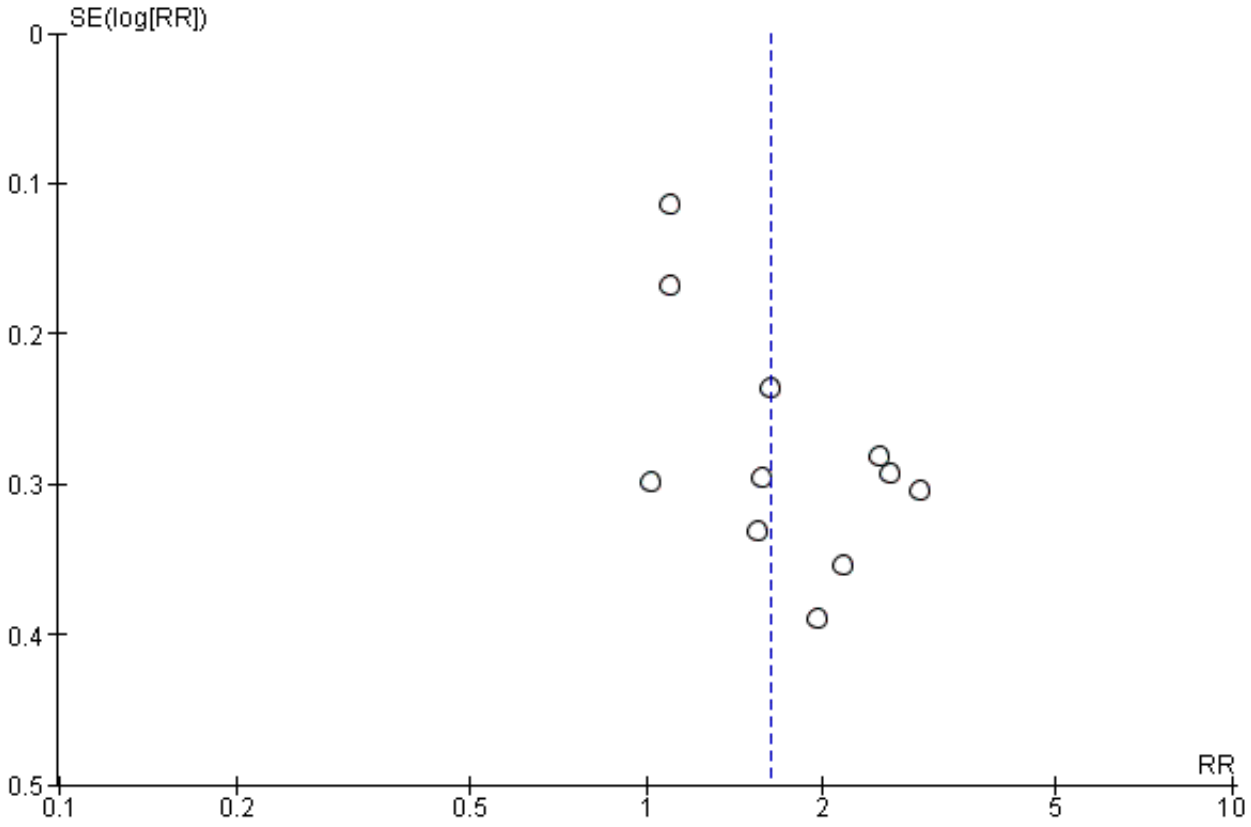
There was no difference in the incidence of cerebral palsy (average RR 1.75, 95% CI 0.84 to 3.63, N = 13,252, 2 trials, random-effects, Analysis 1.3). The quality of the evidence was assessed as moderate (Summary of findings for the main comparison). The data on cerebral palsy are heavily influenced by one small trial (Seattle 1987) that randomised only very preterm babies (less than 32 weeks) and assessed outcomes for 173 babies of birthweight less than 1750 g with a cerebral palsy rate of 19.5% in the CTG group compared with 7.7% in the controls (RR 2.54, 95% CI 1.10 to 5.86). The other trial in this comparison (Dublin 1985) showed no significant difference in the incidence of cerebral palsy (RR 1.20, 95% CI 0.52 to 2.79, N = 13,079) with a cerebral palsy rate of 0.18% in the continuous CTG group and 0.15% in the intermittently monitored group.

There was no difference in the incidence of cord blood acidosis between the groups (Analysis 1.6). The quality of the evidence was assessed as very low, mainly due to very significant heterogeneity and design limitations in many of the included studies (Summary of findings for the main comparison).

For the mother

There was a significant increase in the caesarean section rate in the CTG group (average RR 1.63, 95% CI 1.29 to 2.07, 18,861, 11 trials, Analysis 1.4). However, the quality of this evidence was assessed as low, mainly due to very significant heterogeneity and study design limitations (Summary of findings for the main comparison). Risk difference in the caesarean section rate was 5% (95% CI 2% to 8%), with two-thirds of data coming from Dublin 1985, where the overall caesarean section rate was 2.3%. In addition, the funnel plot indicated the possibility of missing studies (Figure 4).

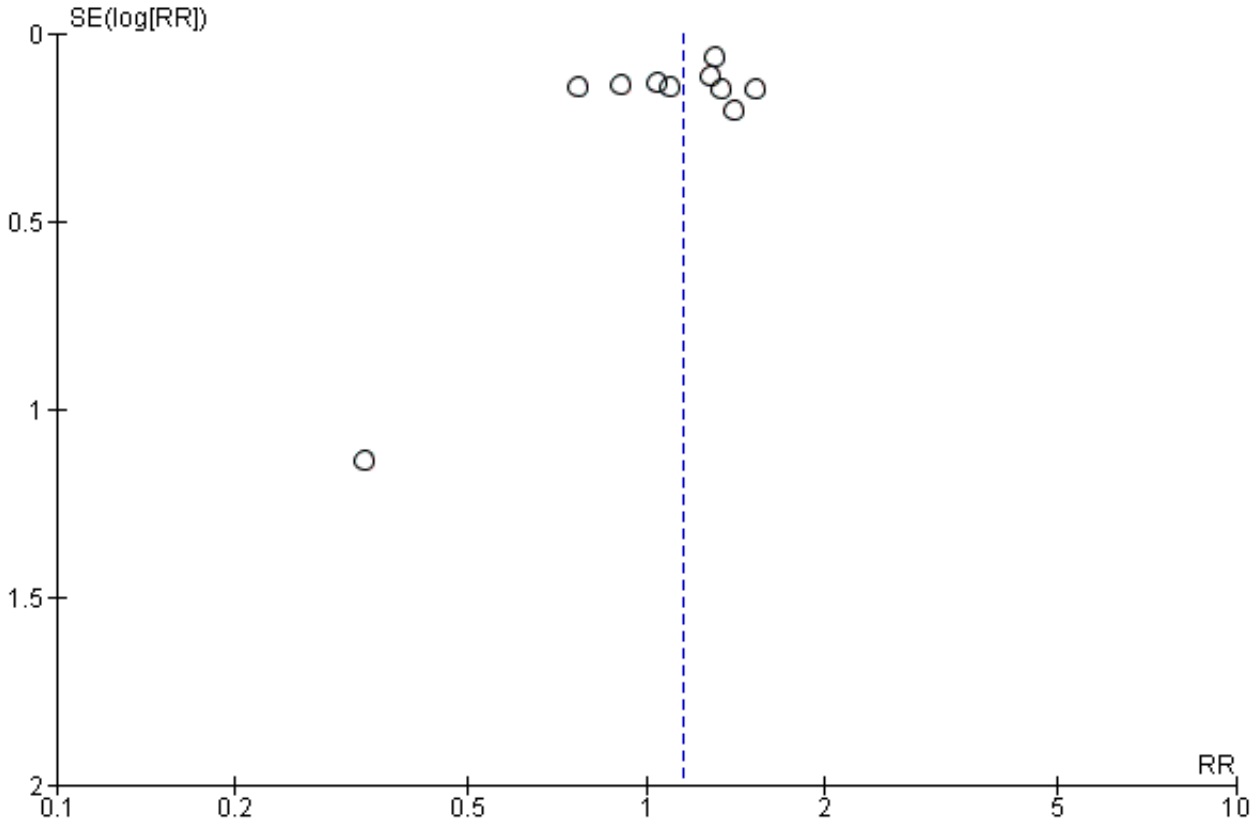
Figure 4. Funnel plot of comparison: 1 Continuous CTG versus intermittent auscultation, outcome: 1.4 Caesarean section (main outcome)



Although numbers needed to treat to benefit or harm (NNTB/NNTH) analyses remain controversial in the context of meta-analysis and should be interpreted with caution, we calculated that there would be one additional caesarean section for every 44 women monitored continuously (95% CI 26 to 96). This calculation was based on the pooled caesarean section rate of 3.6% (337/9313) in the intermittent auscultation group from this meta-analysis. However, in most settings caesarean section rates are likely to be much higher. Assuming a caesarean section rate with intermittent auscultation of around 15%, there would be an additional caesarean section for every 11 women monitored (95% CI 7 to 23).

Continuous CTG was also associated with an increase in instrumental vaginal birth (Analysis 1.5). The funnel plot indicated that some studies might be missing (Figure 5). The quality of this evidence was assessed as low, mainly due to very significant heterogeneity and study design limitations (Summary of findings for the main comparison). There was no difference identified in the use of any pharmacological analgesia (Analysis 1.7), with the quality of the evidence assessed as low (Summary of findings for the main comparison).

Figure 5. Funnel plot of comparison: 1 Continuous CTG versus intermittent auscultation, outcome: 1.5 Instrumental vaginal birth (main outcome)



Other important outcomes

For the infant

There was no evidence of any other benefit or harm for babies in terms of hypoxic Ischaemic encephalopathy (Analysis 1.8), Apgar scores (Analysis 1.10), or admission to neonatal intensive care unit (Analysis 1.12).

For the mother

Women in the continuous CTG group were more likely to have a caesarean section for abnormal fetal heart rate, acidosis or both (Analysis 1.15) and less likely to have a spontaneous vaginal birth (Analysis 1.17). There was no difference in the use of epidural analgesia (Analysis 1.18). The use of fetal blood sampling was reported in two trials (Copenhagen 1985; Dublin 1985) with significantly more sampling tests performed in the continuous CTG group (Analysis 1.13). There were no reported data suitable for analysis for the use of non-pharmacological methods for coping with labour, amniotomy, perineal trauma, inability to adopt preferred position in labour, dissatisfaction in labour and postpartum depression.

Overall findings

Notwithstanding the caution regarding NNTB/NNTH calculations, when the risk of neonatal seizures is around 3 per 1000, 667 women would have to be continuously monitored during labour to prevent one such seizure (95% CI 484 to 1667). There is an opposite effect on caesarean section. Assuming a 3.6% caesarean section rate with intermittent auscultation, there would be 15 more caesarean sections in this cohort associated with preventing one neonatal seizure. However, if caesarean section with intermittent auscultation is higher (15%), 61 extra caesarean sections would be associated with preventing one neonatal seizure.

Continuous CTG versus intermittent auscultation (Subgroup: pregnancy risk status - high/low/unclear or both - Comparison 2)

Of the 12 studies that compared continuous CTG with intermittent auscultation, six included women at increased risk of complications (Denver 1976; Denver 1979; Melbourne 1976; New Delhi 2006; Pakistan 1989; Seattle 1987), three included women at low risk of complications (Dallas 1986; Melbourne 1981; Sheffield 1978) and three studies included both groups of women or did not specify (Athens 1993; Copenhagen 1985; Dublin 1985). There was a significant difference in the impact of CTG monitoring on caesarean section rate depending on the risk status of women (P = 0.004; I^2 = 81.6%), although heterogeneity can be attributed to the group with combined risk rather than to the subgroups where the risk was clearly defined. There were no other statistically significant differences between the subgroups for any other main outcomes.

Subgroups analysis by onset of labour (spontaneous/induced/unclear or both - Comparison 3)

None of the included trials provided separate data for spontaneous and induced labours. Hence, there is no information to determine

if there might be a difference in the impact of CTG for women in spontaneous labour compared with those with induction of labour.

Subgroup analysis by gestational age (preterm/term/unclear or both - Comparison 4)

Of the 12 studies that compared continuous CTG with intermittent auscultation, one included only preterm labours (Seattle 1987). Three studies included only term labours (Copenhagen 1985; Melbourne 1981; Sheffield 1978) and eight studies included both or did not specify (Athens 1993; Dallas 1986; Denver 1979; Denver 1979; Dublin 1985; Melbourne 1976; New Delhi 2006; Pakistan 1989). We found no evidence of a difference between subgroups.

Subgroup analysis by number of babies being monitored (singleton/twin pregnancy/unclear or both - Comparison 5)

Eight studies included only singleton pregnancies (Athens 1993; Dallas 1986; Denver 1976; Melbourne 1981; New Delhi 2006; Pakistan 1989; Seattle 1987; Sheffield 1978) and four included both singleton and twin pregnancies or did not specify (Copenhagen 1985; Denver 1979; Dublin 1985; Melbourne 1976). There was a significant subgroup effect for the rate of neonatal acidosis (P = 0.04; I^2 = 77%) with more acidosis in CTG monitored singletons and less in CTG monitored twins. There was also a subgroup difference in the use of pharmacological analgesia (P = 0.02; I^2 = 83%), but the data were only available for singletons and mixed group with no data for twins only. There were no subgroup differences for the other main outcomes.

Subgroup analysis by access to fetal blood sampling during labour (Comparison 6)

Six studies offered fetal blood sampling alongside the CTG (Copenhagen 1985; Dublin 1985; Melbourne 1976; Melbourne 1981; Pakistan 1989; Seattle 1987), five studies did not use fetal blood sampling (Athens 1993; Dallas 1986; Denver 1976; New Delhi 2006; Sheffield 1978) and one study randomised to three groups, CTG with fetal blood sampling, CTG alone and intermittent auscultation (Denver 1979).

There was a significant subgroup effect on instrumental vaginal birth with apparently more instrumental deliveries (P = 0.04; I^2 = 77%), but less neonatal acidosis (P = 0.04; I^2 = 76.5%) in the fetal blood sampling subgroup. However, there were no subgroup differences for the other main outcomes.

Subgroups by parity (primiparous/multiparous women/unclear or both - Comparison 7)

None of the studies included only primiparous women, one study included only multiparous women (New Delhi 2006) and 11 studies included both primiparous and multiparous women (Athens 1993; Copenhagen 1985; Dallas 1986; Denver 1976; Denver 1979; Dublin 1985; Melbourne 1976; Melbourne 1981; Pakistan 1989; Seattle 1987; Sheffield 1978). As only one of these studies reported results based on the parity of the women involved, it was not possible to perform a meaningful subgroup analysis.

Continuous CTG versus intermittent auscultation (sensitivity analysis: high/low/unclear quality of studies - Comparison 8)

Of the 12 studies that compared continuous CTG with intermittent auscultation, two were considered to be of high methodological quality (Dublin 1985; Melbourne 1976), four studies where considered to be low methodological quality (Athens 1993; Dallas 1986; Melbourne 1981; Pakistan 1989) and methodological quality was unclear for six studies (Copenhagen 1985; Denver 1976; Denver 1979; New Delhi 2006; Seattle 1987; Sheffield 1978).

Removing the low quality trials made very little difference to the analysis for perinatal mortality (Analysis 8.1), neonatal seizures (Analysis 8.2), caesarean section (Analysis 8.4), and instrumental vaginal birth (Analysis 8.5). There were no low quality trials contributing to the cerebral palsy (Analysis 8.3) or any pharmacological analgesia (Analysis 8.7) analyses. Only two studies, one high quality (Dublin 1985) and one low quality (Athens 1993), contributed to the analysis for cord blood acidosis (Analysis 8.6). Removing data from Athens 1993 caused the direction of effect to change in favour of continuous CTG; however, the confidence interval still crossed the line of no effect.

We also investigated the differences between high risk, low risk, and unclear risk trials by interaction tests. It appeared that in a high-quality trial, there was less cord blood acidosis compared with low-quality trials (P = 0.04; I^2 = 76.5%). There was significant subgroup heterogeneity for instrumental vaginal birth (P = 0.007; I^2 = 79.9%), but no clear difference between high- and low-risk subgroups.

Continuous CTG versus intermittent CTG (Comparison 9)

Lund 1994 involved 4044 high-risk pregnant women and found no clear differences between groups for eight of the outcomes specified in this review: caesarean section (Analysis 9.1) instrumental vaginal birth (Analysis 9.2); cord blood acidosis (Analysis 9.3); Apgar score less than seven at five minutes (Analysis 9.4); neonatal ICU admissions (Analysis 9.5); caesarean section for abnormal fetal heat rate pattern and/or fetal acidosis (Analysis 9.6); spontaneous vaginal birth (Analysis 9.7); or epidural anaesthesia (Analysis 9.8).

DISCUSSION

Summary of main results

The main reason for the introduction of continuous intrapartum cardiotocography (CTG) monitoring in clinical practice was a belief that it would reduce rare but devastating outcomes - perinatal death and neonatal hypoxic brain injury - in otherwise healthy babies. However, we found no clear difference in perinatal deaths between pregnancies monitored during labour with continuous CTG compared to those monitored using intermittent auscultation. The overall quality of evidence that underpins this conclusion has been judged as moderate (Summary of findings for the main comparison). It does, however, seem unrealistic to expect that any randomised study of intrapartum interventions in modern maternity care will result in an improvement in perinatal deaths that reaches the conventional level of statistical significance (superiority). For a trial to test a realistic hypothesis that continuous CTG can prevent one death in one thousand births (0.1%), more than 50,000 women would have to be randomised. Therefore, it is more logical to concentrate on short- and long-term childhood morbidity. Unfortunately, very few clinically-relevant neonatal outcomes have been reported consistently in all trials.

For decades, low Apgar scores have been used as a surrogate measure for birth asphyxia and subsequent adverse neurodevelopmental outcomes. Recent evidence has confirmed a strong association between low Apgar score (at five minutes

after birth) and cerebral palsy in both low and normal birthweight infants (Lie 2010). We found no evidence that use of continuous intrapartum CTG monitoring has an impact on Apgar score. However, there were very few babies with clinically significant low Apgar scores in studies that assessed this outcome. Therefore, potentially important differences between the groups cannot be ruled out.

Hypoxic ischaemic encephalopathy, a more robust measure of hypoxic brain injury, was reported in only one study (Athens 1993). In the absence of any meaningful long-term follow-up data, the impact of continuous CTG monitoring on a neonate can only be evaluated based on data from two clinically important outcomes, that is, neonatal seizures and cerebral palsy.

For both neonatal seizures and cerebral palsy, most data were provided by Dublin 1985. At first glance, the data appear contradictory. There was a significant reduction in neonatal seizures in the continuous CTG group, but no impact on cerebral palsy. If anything, the rates of cerebral palsy appear to be higher in the continuous CTG group, although the pooled result did not reach statistical significance. This apparent increase in cerebral palsy in children monitored by CTG comes from Seattle 1987. However, the results from this study, the only study of CTG monitoring during preterm labour, are not significant using 99% confidence intervals. In addition, this study excluded infants with birthweights of more than 1750 g (34% of randomised cohort), which may be a source of bias. Given that all other outcomes in this trial, including caesarean section rates, neonatal seizures and deaths were almost identical, this may have been a chance finding and should be interpreted with caution.

It is now generally accepted that cerebral palsy is more often caused by antepartum, rather than intrapartum, events (Palmer 1995). Therefore, it may be unrealistic to expect that intrapartum interventions will have the capacity to achieve a significant reduction in cerebral palsy. There are, clearly, some cases of cerebral palsy that are a direct consequence of intrapartum hypoxic injury. These cases are very rare, and systematic reviews of randomised trials are unlikely to have sufficient power to test intrapartum CTG as a method to reduce cerebral palsy caused by acute and avoidable intrapartum events.

The reduction in seizures associated with continuous CTG monitoring is important, but must be interpreted cautiously in the absence of good quality long-term follow-up data. It has been suggested that seizures may be a "sentinel event" of a peripartum adversity that does not necessarily always manifest itself as hypoxic encephalopathy (Dennis 1978; Derham 1985, Keegan 1985; Lien 1995; Spellacy 1985). When asphyxia, infection, brain malformations and metabolic causes are excluded, some neonatal seizures are associated with cerebral infarction or neonatal stroke (Estan 1997; Lien 1995). Although the underlying causes are not well understood, neonatal seizures may have long-term consequences other than cerebral palsy. One longitudinal study found that some babies who had neonatal seizures were classified as normal at five years and had normal overall intelligence in adolescence as assessed by IQ tests, but had some abnormal results on detailed neuropsychological testing (Temple 1995). Clearly, there is a need for comprehensive long-term follow-up of the randomised cohorts that is not limited to extreme adverse outcomes such as cerebral palsy, but also includes more subtle neuropsychological assessment.

The results of this review demonstrate that continuous CTG monitoring leads to an increase in caesarean sections. Such an effect of continuous CTG is clinically plausible because CTG monitoring leads to more interventions (e.g. fetal blood sampling, amniotomy) and more diagnoses of presumed fetal compromise for which emergency caesarean section is seen as the only safe management option. However, the overall quality of evidence for this outcome was judged as low (Summary of findings for the main comparison). Therefore, the observed increase must be interpreted cautiously.

It is noteworthy that size and direction of the effect on caesarean section was consistent for prespecified subgroups, including high-quality trials and trials where clinicians had access to intrapartum fetal blood sampling. Subgroup interaction test was only significant (I^2 = 81.6%) for studies in low-risk, high-risk and mixed risk status, but heterogeneity came from a mixed group. The impact of CTG monitoring on caesarean section in low-risk and high-risk populations appears to be virtually identical, which is contrary to recommendations from many professional bodies providing guidance on intrapartum fetal monitoring.

There was some evidence that labour was more painful in the continuous CTG group, but the statistically significant increase in the need for any analgesia included general anaesthesia. Therefore, it is likely that this difference was caused by an increase in the number of caesarean sections, rather than necessarily more painful labour. Women report more pain when lying on their backs during labour. At the times when the studies in this review were undertaken (between 1976 and 1994), women in the intermittent auscultation group may well also have been on their backs and not using mobility and positions to help them with their labours. There were no data from the trials included in the review to enable analysis of this potential confounder.

We prespecified several subgroups that could have been expected to influence the direction and size of the differences compared with results when all trials were considered together. We were conscious that any differences among subgroups and overall results would have to be interpreted with extreme caution (Rothwell 2005). With this proviso, we found no subgroup differences of clinical importance, but the number of trials and women in subgroups was relatively small.

Overall completeness and applicability of evidence

Clearly, the lack of long-term follow-up data and inadequate reporting of the data according to the clinically important subgroups is regrettable and limits the applicability of the evidence.

There are also two other issues that should be considered in the applicability of the evidence reviewed here:

1. Methods of intermittent ascultation differed among included trials regarding frequency, duration and timing in relation to contractions; some recorded fetal heartbeat during and after contractions, others immediately following contractions, and others were not specific (Table 3). The trials also differed in additional assessments of fetal wellbeing. For example, in Dublin 1985, which is a large contributor of meta-analysis weight across most review outcomes, all women had an artifical rupture of membranes performed within an hour of admission. In addition to routine artifical rupture of membranes, in Dublin

1985 fetal blood sampling was performed for all women who had not delivered within eight hours (1.2% of women in the CTG group and 2.1% of women in the intermittent auscultation group). Such practices may be less generalisable to current approaches to care of women during labour.

2. With the exception of New Delhi 2006, all included studies were conducted in the 1970s, 1980s, and early 1990s. Since then, there have been substantial developments in equipment used to perform cardiotocography and a strong emphasis on education for all those involved in CTG interpretation (which in some jurisdictions is mandatory), and continuous review and refinement of interpretation criteria. Nevertheless, most technological developments in intrapartum assessment of fetal wellbeing, including for example, ST waveform analysis (Neilson 2015), expert systems (Lutomski 2015) and computerised analysis have not shown substantive clinical benefits. In addition, there was insufficient evidence available to demonstrate a substantial benefit for applied artificial intelligence, such as expert systems, in improving interpretation of fetal heart rate tracings (Lutomski 2015). This might suggest that the data related to the impact of CTG monitoring is still relevant to current practice.

Quality of the evidence

The methodological quality of the included studies was mixed. All included studies were assessed at high risk of performance bias, all were unclear or high risk of detection bias, and all were unclear risk of reporting bias. Figure 1 depicts a summary of risk of bias assessment for the included studies.

We used GRADEpro software to assess evidence quality for selected GRADE outcomes; for neonatal seizures the evidence was rated moderate, evidence for cord blood acidosis was rated very low, and the remaining GRADE outcomes (perinatal mortality, cerebral palsy, caesarean section, instrumental vaginal birth and any pharmacological analgesia) were all assessed as low quality. Evidence was downgraded for risk of bias, imprecision of effect estimates and high heterogeneity between studies. These ratings are summarised in Summary of findings for the main comparison.

Potential biases in the review process

Our selection of outcomes in general and main outcomes in particular might have been influenced by our knowledge of the published literature and the first Cochrane review on this topic (Thacker 2001).

Agreements and disagreements with other studies or reviews

Some large cohort studies suggest much more profound benefit on neonatal morbidity and mortality (Chen 2011). Some observational data also suggest benefit from fetal blood sampling during labour in cases of suboptimal CTG (Stein 2006). We found no evidence that the increase in caesarean section rate was greater if fetal blood sampling was unavailable; nor did access to fetal blood sampling influence the difference in neonatal seizures or any other prespecified outcome.

AUTHORS' CONCLUSIONS

Implications for practice

Translating the evidence from this review into clinical practice poses significant challenges. One would hope that the quality of cardiotocography (CTG) equipment, interpretation and training have improved over the years making the external validity of much of the data included in this review questionable.

In most included studies, intermittent auscultation was carried out according to the strict protocols in hospital settings with quick recourse to continuous monitoring and intervention if required. In some trials, most notably Dublin 1985, intact fetal membranes were ruptured at the earliest opportunity to confirm absence of meconium, and women had one-to-one care from a midwife. This monitoring package differs significantly from practices in some modern birth settings (including, for example, stand-alone midwifery units) where artificial rupture of membranes is avoided as long as possible, and where mobilisation and normality are promoted. In addition, one-to-one care by a midwife, or a nurse-midwife, seems hard to implement in many healthcare settings and is likely to be an important contributory factor for effectiveness (or lack of it) of both types of fetal heart rate monitoring.

With this proviso, women should be informed that continuous CTG during labour is associated with a reduction in the incidence of neonatal seizures, has no obvious impact on cerebral palsy or perinatal mortality, but is associated with an increase in the incidence of caesarean section and instrumental vaginal births. The adverse affects of operative births are well described, albeit that longer term morbidity data are less available than shorter term morbidity data. The possible long-term effects of preventable neonatal seizures remain unknown. Women also need to be informed of the loss of mobility associated with the use of continuous CTG in labour.

Women, practitioners and policy makers need to carefully consider the absence of evidence that continuous CTG monitoring has a different impact on caesarean section and neonatal seizures in low- and high-risk populations and that there is an absence of evidence from included trials of a beneficial effect for fetal blood sampling.

The risk-benefit debate will continue to focus on caesarean section and neonatal seizures. Given the perceived conflict between the risk for the mother (increased caesarean section and instrumental vaginal delivery rate) and benefit for the baby (decreased incidence of neonatal seizures), it is difficult to make quality judgments about which effect is more important. The issue of effectiveness is particularly important. CTG advocates will continue to argue that lack of clear long-term benefit for the child is not proof that intermittent auscultation is safe. However, it would seem reasonable to base clinical decisions on the evidence we currently have rather than on unknown risks of unknown quantity. Obviously, the risk-benefit assessment will vary among individuals, policy makers and healthcare settings. The real challenge is how best to convey this uncertainty to women and help them to make informed choices without compromising the normality of labour.

Implications for research

A question remains about whether future randomised trials should measure efficacy (the intrinsic value of continuous CTG in trying to prevent adverse neonatal outcomes under optimal clinical

conditions) or effectiveness (the effect of this technique in routine clinical practice).

Along with the need for further investigations into the long-term effects of operative births for women and babies, much remains to be learned about the causation and possible links between antenatal or intrapartum events, neonatal seizures and long-term neurodevelopmental outcome, bearing in mind the changes in clinical practice over the intervening years (one-to-one-support during labour, caesarean section rates). The large number of babies randomised in this review will now have reached adulthood, and could potentially provide us with a unique opportunity to clarify if a reduction in neonatal seizures is something inconsequential that should not greatly influence women's and clinicians' choices, or if seizure reduction leads to long-term benefits for babies. Defining meaningful neurological and behavioural outcomes that could be measured in large cohorts of young adults poses huge challenges.

Data should also be collected from this cohort of women and babies, while medical records still exist, to describe, where possible, the women's mobility and positions during labour and birth, and clarify if these might impact on outcomes. Research should also investigate the possible contribution of the supine position to adverse outcomes for the baby, and address the question of whether the use of mobility and positions can reduce the already low incidence of neonatal seizures and improve psychological outcomes for women.

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* Indicates the major publication for the study

CHARACTERISTICS OF STUDIES

Characteristics of included studies *[ordered by study ID]*

Athens 1993

Methods	RCT. Assignment by coin toss on admission. Mothers and obstetricians not blinded; neonatologists collecting data on neonatal outcomes were blinded.
Participants	Inclusion: Mixed risk. Women with a singleton fetus at 26 or more weeks' gestation admitted in spontaneous labour or for induction of labour. Total of 1428 women participated. Exclusion: Women with known fetal congenital or chromosomal abnormalities.
Interventions	Intervention: Continuous CTG without FBS • CTG: external unless trace poor when internal CTG used • N = 746 Comparison: IA • N = 682
Outcomes	Labour onset, oxytocin administration, duration of labour, premature rupture of the membranes, meconium-stained liquor, mode of delivery, analgesia/anaesthesia, 'non reassuring' FHR patterns, length of maternal hospital stay, postpartum maternal morbidity (infection or blood transfusion), duration of 'good quality tracing'. Presentation at birth, birthweight (< 2500, 2500 to 4000, > 4000), Apgar score < 7 @ 1 min and @ 5 min, cord arterial pH < 7.10, neonatal resuscitation, NICU admission, assisted ventilation, length of neonatal hospital stay, neonatal complications (none, HIE, intraventricular haemorrhage, seizures, hypotonia, necrotising enterocolitis, respiratory distress, sepsis, hyperbilirubinaemia, hypoglycaemia, congenital anomalies), intrapartum fetal death, neonatal death, perinatal death, perinatal death from hypoxia. Outcomes analysed: caesarean deliveries, operative vaginal deliveries, 1 minute Apgar < 4 and < 7, neonatal seizures, NICU admissions, length of stay, and perinatal death. Outcomes not analysed: presentation, labour, labour duration, PROM, meconium, maternal infection or blood transfusion.
Overall risk of bias	High risk of bias including high risk of bias for random sequence generation and concealment of allocation.
Notes	Study period: October 1990 to June 1991. Subgroups: Mixed risk; mixed onset of labour; mixed gestation; singletons; no FBS; mixed parity; low quality.

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	High risk	"…assigned on admission by a coin toss..." However, unexplained high imbalance in numbers allocated to groups (746 EFM and 682 IA) suggests a high risk of bias in sequence generation

Athens 1993 *(Continued)*

Allocation concealment (selection bias)	High risk	No information given. The use of coin toss to generate the random sequence without this information suggests there was high risk of bias in allocation concealment
Blinding of participants and personnel (performance bias) All outcomes	High risk	Although not documented, we judged that women and clinicians were not blind to the interventions used
Blinding of outcome assessment (detection bias) All outcomes	High risk	Neonatologists assessing neonatal outcomes were blinded to allocation. Not stated if other outcomes were assessed blindly but unlikely
Incomplete outcome data (attrition bias) All outcomes	Low risk	Data on all 1428 women were available
Selective reporting (reporting bias)	Unclear risk	Trial protocol not available for assessment
Other bias	Low risk	Appears to be free of other sources of bias

Copenhagen 1985

Methods	RCT. Weekly allocation to either group by random sampling. Method of randomisation unclear.
Participants	Inclusion: Mixed risk Among 1410 women who fulfilled the criteria for entering the study, 349 refused to participate (primarily due to preference for 1 form of monitoring). Total of 969 women participated. Baseline outcomes collected for non-participating group of women. 3 twins in CTG group and 6 twins in IA group. Exclusion: Women with diabetes
Interventions	Intervention: Continuous CTG in conjunction with FBS • CTG: external or internal • N = 482 Comparison: IA • N = 487
Outcomes	FHR pattern, corrective procedures for pathological FHR pattern (oxygen, change of maternal position, CS, vacuum extraction), indications for termination of labour (mechanical disproportion, bleeding, cord prolapse, maternal disease, fetal disease, lack of progression, other), presentation at birth, administration of oxytocin, analgesia/anaesthesia. Apgar score 0 to 3, 4 to 6, 7 to 10 @ 1 min and @ 5 min, gestational age (including appropriate for gestational age, small-for-gestational age, large-for-gestational age), weight, NICU admissions, asphyxia, oxygen/CPAP requirement, intubation, ventilation, post-asphyxia pallor, seizures, irritability, neonatal infection, intrapartum death, antepartum death.

Copenhagen 1985 *(Continued)*

Overall risk of bias	Moderate risk of bias including unclear risk of bias for random sequence generation and concealment of allocation.
Notes	Study period: January 1981 to January 1982 (date women expected to give birth). Subgroups: Mixed risk; mixed onset of labour; term; both singletons and twins; FBS; mixed parity; unclear quality.

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	"…by random sampling…"
Allocation concealment (selection bias)	Unclear risk	Unpublished paper refers to 'The weekly allocation was furthermore selected...' This suggests that allocation may have been done on a weekly basis but it is unclear
Blinding of participants and personnel (performance bias) All outcomes	High risk	Although not documented, we judged that women and clinicians were not blind to the interventions used
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	No information given
Incomplete outcome data (attrition bias) All outcomes	Low risk	Data on all 969 women available
Selective reporting (reporting bias)	Unclear risk	Trial protocol not available for assessment
Other bias	Low risk	Appears to be free of other sources of bias (ITT information in the unpublished paper from this study)

Dallas 1986

Methods	Quasi-RCT. Randomisation by alternate months; selective monitoring (policy of using monitoring only in high-risk pregnancies) versus universal monitoring (use of a monitor for every pregnancy in which the fetus was considered viable i.e. irrespective of risk status).
Participants	34,995 women included in the study. Data were extracted for 14,618 women with pregnancies at low risk; 7288 in universal monitoring group where all women monitored by CTG, and 7330 in selective monitoring where women at low risk monitored by IA.
Interventions	Intervention: Continuous CTG • CTG: no information on external or internal • N = 7288 Comparison: IA • N = 7330

Dallas 1986 *(Continued)*

Outcomes	Abnormal FHR pattern, CS, intrapartum fetal deaths, neonatal deaths, assisted ventilation, Apgar score < 5 @ 5 min, NICU admission, seizures.
Overall risk of bias	High risk of bias including high risk of bias for random sequence generation and concealment of allocation.
Notes	Study period: information not available. Subgroups: Low risk; mixed onset of labour; mixed gestation; singletons; no FBS; mixed parity; low quality.

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	High risk	Randomisation by alternate months
Allocation concealment (selection bias)	High risk	Randomisation by alternate months
Blinding of participants and personnel (performance bias) All outcomes	High risk	Although not documented, we judged that women and clinicians were not blind to the interventions used
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	No information provided
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	No information provided
Selective reporting (reporting bias)	Unclear risk	Trial protocol not available for assessment
Other bias	Low risk	The study appears to be free of other sources of bias

Denver 1976

Methods	RCT. Randomised sealed envelope with participants with even numbers having CTG while participants with odd numbers had IA.
Participants	Women at high risk on point system rating; in addition those with meconium stained fluid, needing oxytocin or abnormal fetal heart tones during labour were eligible to participate. Total of 483 women participated.
Interventions	Intervention: Continuous CTG without FBS • CTG: internal • N = 242 Comparison: IA

Denver 1976 *(Continued)*

- N = 241

Outcomes	FHR pattern, CS, instrumental vaginal deliveries, anaesthesia, umbilical cord pH, mean Apgar scores and Apgar scores ≤ 7 and > 7 @ 1 min and @ 5 min, NICU admissions, temperate abnormalities, jaundice, lethargy, seizures, jitteriness, spontaneous respiration, intubation, ventilation.
Overall risk of bias	Moderate risk of bias including unclear risk of bias for random sequence generation and concealment of allocation.
Notes	Study period: information not available. IA group had a CTG monitor attached, which was turned off at bedside but which was recorded on a covered monitor in the hallway. This CTG was not available to clinicians during the woman's labour. Subgroups: High risk; mixed onset of labour; mixed gestation; singletons; no FBS; mixed parity; unclear quality

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	'… previously randomised sealed envelope…' Women with even number allocated to CTG and women with odd number allocated to bedside monitor turned off
Allocation concealment (selection bias)	Unclear risk	Insufficient information provided. Though randomised sealed envelopes were used, it is not clear if they were opaque and sequentially numbered. Also women with even number allocated to CTG and women with odd number allocated to bedside monitor turned off
Blinding of participants and personnel (performance bias) All outcomes	High risk	Although not documented, we judged that women and clinicians were not blind to the interventions used
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	No information provided
Incomplete outcome data (attrition bias) All outcomes	Low risk	Data on all 483 women were reported
Selective reporting (reporting bias)	Unclear risk	Trial protocol not available for assessment
Other bias	Low risk	Appears to be free of other sources of bias

Denver 1979

Methods	RCT. Allocation by random numbers in sealed envelopes.
Participants	Women at high risk in labour. Total of 690 women participating with 5 sets of twins (695 infants).
Interventions	Intervention 1: Continuous CTG with FBS

Denver 1979 *(Continued)*

- CTG: external until internal feasible
- N = 229

Intervention 2: Continuous CTG without FBS

- CTG: external until internal feasible
- N = 230

Comparison: IA

- N = 231

Outcomes	Pre-eclampsia, amnionitis, FHR patterns, CS, instrumental vaginal deliveries, anaesthesia, maternal postpartum infections, oxytocin administration during labour, meconium. Gestational age (including appropriate for gestational age, small-for-gestational age, large-for-gestational age), mean Apgar score and Apgar score 0 to 3, 4 to 7, 8 to 10 @ 1 min and @ 5 min, umbilical cord blood gases (pH, pO_2, pCO_2), respiratory distress, pneumonia, seizures, sepsis, meningitis, NICU admission, required antibiotics, Bayley scales and Milani-Comparetti tests at 9 months of age.
Overall risk of bias	Moderate risk of bias including unclear risk of bias for random sequence generation and concealment of allocation.
Notes	Study period: July 1975 to July 1977. Intervention 1 and Intervention 2 - data pooled to provide overall data for CTG. Subgroups: High risk; mixed onset of labour; mixed gestation; singletons and twins; no FBS; mixed parity; unclear quality

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	No information reported
Allocation concealment (selection bias)	Unclear risk	"…allotted a sealed envelope…" but no information on if opaque or if numbered sequentially
Blinding of participants and personnel (performance bias) All outcomes	High risk	Although not documented, we judged that women and clinicians were not blind to the interventions used
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	No information provided
Incomplete outcome data (attrition bias) All outcomes	Low risk	Some low levels of attrition for some outcomes but insufficient to impact on outcomes
Selective reporting (reporting bias)	Unclear risk	Trial protocol not available for assessment
Other bias	Low risk	Appears to be free of other sources of bias

Dublin 1985

Methods	RCT. Random allocation by opening the next envelope in a series of serially numbered, opaque, sealed envelopes
Participants	Women at > 28 weeks' gestation, in labour, clear liquor previously demonstrated. Mixed risk. Total of 12,964 women participated
Interventions	Intervention: Continuous CTG in conjunction with FBS • CTG: internal • N = 6474 Comparison: IA • N = 6490
Outcomes	Use of FBS, scalp pH values, randomisation-delivery interval, oxytocin use, analgesia, CS, operative vaginal deliveries, Apgar score < 3 @ 1 min and @ 5 min, intubation, NICU admission, umbilical cord venous pH values neonatal trauma (e.g. fractured clavicle, facial nerve injury, intrapartum death, neonatal death, seizures, abnormalities of tone and reflexes, primary cause of stillbirths and neonatal deaths, labour length, cerebral palsy at 4 years of age.
Overall risk of bias	Low risk of bias (no limitations for random sequence generation and allocation concealment).
Notes	Study period: March 1981 to April 1983. Zelen design. FBS was performed when the duration of labour exceeded 8 hours. This occurred in 77/6474 (1.2%) of women in the CTG arm and 139/6486 (2.1%) of women in the IA arm. Subgroups: Mixed risk (separated data only available for seizures); mixed onset of labour; mixed gestation; singletons and twins; FBS; mixed parity; high quality.

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	The sequence was generated using a random numbers table, at a central register, to randomly select from the range of permutations available within the balanced blocks. (personal communication from Adrian Grant, 24.04.12)
Allocation concealment (selection bias)	Low risk	"…serially numbered, sealed, opaque envelopes…"
Blinding of participants and personnel (performance bias) All outcomes	High risk	Although not documented, we judged that women and clinicians were not blind to the interventions used.
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	No information provided other than other than below: 'All 30 children who had survived after neonatal seizures, and 125 (91%) of the remaining 138 children whose neurological status had been judged to be abnormal, underwent a general physical and detailed neurological examination by an experienced paediatrician who was "blind" both to the trial allocation and to the nature of the neonatal neurological abnormality.'

Dublin 1985 *(Continued)*

Incomplete outcome data (attrition bias) All outcomes	Low risk	No exclusions after randomisation
Selective reporting (reporting bias)	Unclear risk	Trial protocol not available for assessment
Other bias	Low risk	Appears to be free of other sources of bias

Lund 1994

Methods	RCT. Shuffled opaque envelopes in randomly permuted blocks.
Participants	Women with low to moderate risk factors for complications during labour. Total of 4044 women participated.
Interventions	Intervention: Continuous CTG with FBS • CTG: no information on external or internal • N = 2029 Comparison: Intermittent CTG with FBS • CTG: no information on external or internal • N = 2015
Outcomes	FHR pattern, time from admission to delivery, length of labour, duration of CTG, CS, instrumental vaginal deliveries, normal deliveries, umbilical cord arterial pH values, Apgar score < 7 @ 1 min and 5 min, NICU admission.
Overall risk of bias	Low risk of bias (unclear risk of bias for random sequence generation and low risk for allocation concealment)
Notes	Study period: October 1989 to May 1991. Subgroups: these analyses were not undertaken because this study compared continuous with intermittent CTG

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	No information provided, although possibly random sequence due to reference to '…randomly permuted blocks…'
Allocation concealment (selection bias)	Low risk	"…opening an opaque envelope from a pack of shuffled envelopes in randomly permuted blocks…"
Blinding of participants and personnel (performance bias) All outcomes	High risk	Although not documented, we judged that women and clinicians were not blind to the interventions used
Blinding of outcome assessment (detection bias)	Unclear risk	No information provided

Lund 1994 *(Continued)*

All outcomes		
Incomplete outcome data (attrition bias) All outcomes	Low risk	No exclusions after randomisation
Selective reporting (reporting bias)	Unclear risk	Trial protocol not available for assessment
Other bias	Low risk	Appears to be free of other sources of bias

Melbourne 1976

Methods	RCT. Randomised cards in sealed, consecutively numbered envelopes.
Participants	Women at high risk. Total of 350 women participated.
Interventions	Intervention: Continuous CTG with FBS • CTG: external • N = 175 Comparison: IA • N = 175
Outcomes	Length of labour, induction-delivery interval, oxytocin use, IV fluid volume use, ketonuria, analgesia, CS, instrumental vaginal deliveries, maternal infection. Apgar score (mean grouped) 0 to 3, 4 to 6, 7 to 10 (? timing), resuscitation, NICU admission, twitching, apneic episodes, hypotonia, convulsions, tachypnoea, high-pitched cry, hypertonus, neonatal infection, umbilical cord arterial and venous blood gases.
Overall risk of bias	Low risk of bias (no limitations for random sequence generation and allocation concealment).
Notes	Study period: March 1974 to April 1975. Subgroups: High risk; mixed onset of labour; mixed gestation; singletons and twins; FBS; mixed parity; high quality.

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	"…randomised cards…"
Allocation concealment (selection bias)	Low risk	"…sealed consecutively numbered envelopes…"
Blinding of participants and personnel (performance bias) All outcomes	High risk	Although not documented, we judged that women and clinicians were not blind to the interventions used

Melbourne 1976 *(Continued)*

Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	No information provided
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	1 of the 8 clinicians removed all the women in his care from the trial, although it is not reported how many women this was. So it is unclear if this may have introduced bias
Selective reporting (reporting bias)	Unclear risk	Trial protocol not available for assessment
Other bias	Low risk	Appears to be free of other sources of bias

Melbourne 1981

Methods	RCT. Randomised cards; envelopes unsealed; biased randomisation in 1 of the participating hospitals; 62 low-parity women excluded post-hoc to correct for imbalance in randomisation.
Participants	Women at low risk. Total of 989 women participated. Randomisation was open and there was a disproportionate number of low-parity women in the monitored group. Numbers were adjusted by random elimination of 62 women. Analysis was undertaken using the corrected figures.
Interventions	Intervention: Continuous CTG without FBS • CTG: external until membranes ruptured then internal • N = 445 Comparison: IA • N = 482
Outcomes	Analgesia, ketonuria, CS, instrumental vaginal deliveries, normal deliveries. Apgar score 0 to 3, 4 to 6, 7 to 10 @ 1 min, days in 'isolette', days in nursery, phototherapy, neonatal death, neurological signs and symptoms (unspecified).
Overall risk of bias	Moderate risk of bias including high risk of bias for concealment of allocation.
Notes	Study period: no information available. Subgroups: Low risk; mixed onset of labour; term; singletons; FBS; mixed parity; low quality.

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	"…randomization sequences were used…"
Allocation concealment (selection bias)	High risk	Envelopes were not sealed at 1 of the hospitals and this created more low-parity women in the monitored group. This was corrected by random elimination

Melbourne 1981 *(Continued)*

Blinding of participants and personnel (performance bias) All outcomes	High risk	Although not documented, we judged that women and clinicians were not blind to the interventions used
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	No information provided
Incomplete outcome data (attrition bias) All outcomes	High risk	Women were randomly excluded from 1 group to balance the difference in parity
Selective reporting (reporting bias)	Unclear risk	Trial protocol not available for assessment
Other bias	Low risk	Appears to be free of other sources of bias

New Delhi 2006

Methods	RCT but no details on study design
Participants	Women at high risk. 100 women who had 1 previous low-transverse CS. For this pregnancy, singleton and cephalic.
Interventions	Intervention: Continuous CTG • N = 50 Comparison: IA • N = 50
Outcomes	Vaginal birth; CS; forceps; PPH; infection (fever); mean birthweight; Apgar scores; admission to NICU; assisted ventilation; neonatal morbidity.
Overall risk of bias	Moderate risk of bias including unclear risk of bias for random sequence generation and concealment of allocation.
Notes	Study period: no information No good information on study methodology. Subgroups: High risk; mixed onset of labour; mixed gestation; singletons; no FBS; multiparity; unclear quality

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	"...divided randomly..."

New Delhi 2006 *(Continued)*

Allocation concealment (selection bias)	Unclear risk	"...divided randomly..."
Blinding of participants and personnel (performance bias) All outcomes	High risk	Although not documented, we judged that women and clinicians were not blind to the interventions used
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	No information provided
Incomplete outcome data (attrition bias) All outcomes	Low risk	All 100 women's data were available
Selective reporting (reporting bias)	Unclear risk	Trial protocol not available for assessment
Other bias	Low risk	Appears to be free of other sources of bias

Pakistan 1989

Methods	RCT. Randomisation by woman selecting 1 of 200 sealed, opaque, unnumbered envelopes.
Participants	Women at high risk (all participants had meconium stained liquor). Total of 200 women participated with 100 in the CTG group and 100 in the IA group.
Interventions	Intervention: Continuous CTG with FBS • CTG: external • N = 100 Comparison: IA • N = 100
Outcomes	Apgar score < 7 @ 1 min and @ 5 min, CS, instrumental vaginal deliveries, normal deliveries, stillbirths, early neonatal deaths.
Overall risk of bias	High risk of bias (including unclear risk of bias for random sequence generation and high risk of bias for concealment of allocation.
Notes	Study period: 1988 to 1989. Data extracted from unpublished trial lodged with the Cochrane Pregnancy and Childbirth Editorial Office in Liverpool, UK. Subgroups: High risk; mixed onset of labour; mixed gestation; singletons; FBS; mixed parity; low quality.

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**

Pakistan 1989 *(Continued)*

Random sequence generation (selection bias)	Unclear risk	"Randomisation was effected by the woman selecting one of two hundred... ...envelopes...". It is unclear just what this means
Allocation concealment (selection bias)	High risk	"Randomisation was effected by the woman selecting one of two hundred sealed, opaque, unnumbered envelopes containing a card indicating the type of monitoring to be employed."
Blinding of participants and personnel (performance bias) All outcomes	High risk	"…blinding of the allocated intervention was not feasible."
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	No information provided
Incomplete outcome data (attrition bias) All outcomes	Low risk	No women were excluded after randomisation
Selective reporting (reporting bias)	Unclear risk	Trial protocol not available for assessment
Other bias	Low risk	Appears to be free of other sources of bias

Seattle 1987

Methods	RCT. Randomisation by numbered, sealed envelopes.
Participants	Women at high risk. Preterm labour (28 to 32 weeks' gestation), estimated fetal weight 700 g to 1750 g. Total of 386 women participated with 188 in the CTG group and 188 in the IA group. Assessing birthweights under 1750 g left 122 in the CTG group and 124 in the IA group.
Interventions	Intervention: Continuous CTG with FBS • CTG: external until rupture of membranes then internal • N = 188 women randomised but 66 excluded from analysis because of low infant birthweight Comparison: IA • N = 188 women randomised but 64 excluded from analyses because of low infant birthweight
Outcomes	Use of tocolytic agents/antenatal glucocorticoids/oxytocin, regional anaesthesia, premature rupture of membranes, CS. Birthweight, sex of infant, Apgar score 0 to 3 and 4 to 10 @ 1 min and @ 5 min, umbilical cord blood gases, intracranial haemorrhage, severe respiratory distress syndrome, seizures, perinatal death.
Overall risk of bias	Moderate risk of bias including unclear risk of bias for random sequence generation and concealment of allocation.
Notes	Study period: Nov 1981 to Feb 1985. Subgroups: High risk; mixed onset of labour; preterm; singletons; FBS; mixed parity; unclear quality.

Seattle 1987 *(Continued)*

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	No information provided other than 'Randomization cards'
Allocation concealment (selection bias)	Unclear risk	'ID numbers were consecutive, and to enter a patient the next consecutive envelope was chosen.' (Luthy 1987)
Blinding of participants and personnel (performance bias) All outcomes	High risk	Although not documented, we judged that women and clinicians were not blind to the interventions used
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	'…investigators assessing neurologic development were unaware of the monitoring technique used.' No information on blinding for other outcomes
Incomplete outcome data (attrition bias) All outcomes	High risk	130/376 (34%) women were excluded after randomisation because birthweight > 1750 g and authors wished to study babies < 1750 g. Similar proportion of exclusions from each group but we still considered there to be high risk of bias
Selective reporting (reporting bias)	Unclear risk	Trial protocol not available for assessment
Other bias	Low risk	Appears to be free of other sources of bias

Sheffield 1978

Methods	RCT. Sealed envelopes; randomisation details not described.
Participants	Women with low risk (high risk women excluded). Total of 504 women participated.
Interventions	Intervention: Continuous CTG without FBS • CTG: internal • N = 253 Comparison: IA • N = 251
Outcomes	Analgesia/anaesthesia, duration of labour, intra or postpartum pyrexia, length of maternal postpartum stay. Birthweight, congenital anomalies, length of hospital stay, type of labour onset, CS, instrumental vaginal deliveries, normal deliveries, Apgar score (6 or less @ 1 min), NICU admission (including reasons for admission), hypertonicity, umbilical cord blood gases, perinatal deaths.
Overall risk of bias	Moderate risk of bias including unclear risk of bias for random sequence generation and concealment of allocation.
Notes	Study period: July 1976 to June 1977.

Sheffield 1978 *(Continued)*

Subgroups: Low risk; mixed onset of labour; term; singletons; no FBS; mixed parity; unclear quality.

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	No information provided
Allocation concealment (selection bias)	Unclear risk	"…allocated a sealed envelope…" It is unclear if these were opaque and numbered sequentially
Blinding of participants and personnel (performance bias) All outcomes	High risk	Although not documented, we judged that women and clinicians were not blind to the interventions used
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	No information provided
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	81/565 (14%) of women were excluded but it is unclear if this was before or after randomisation
Selective reporting (reporting bias)	Unclear risk	Trial protocol not available for assessment
Other bias	Low risk	Appears to be free of other sources of bias

CPAP: continuous positive airways pressure
CS: caesarean section
CTG: cardiotocography
EFM: electronic fetal monitoring
FBS: fetal blood sampling
FHR: fetal heart rate
HIE: hypoxic ischaemic encephalopathy
IA: intermittent auscultation
ITT: intention-to-treat
IV: intravenous
min: minutes
NICU: neonatal intensive care unit
PPH: postpartum haemorrhage
PROM: preterm rupture of membranes
RCT: randomised controlled trial

Characteristics of excluded studies *[ordered by study ID]*

Study	Reason for exclusion
Greece 2012	Study design compared CTG with CTG plus Doppler
Harare 1994	This randomised study did not include continuous CTG. 4 randomised groups received (i) CTG 10 minutes in every 30 minutes, (ii) Doppler ultrasound monitoring by research midwife, (iii) Pinard stethoscope by research midwife or (iv) routine auscultation by Pinard (last 10 minutes of every 30 minutes)

Study	Reason for exclusion
Ioannina 2001	Non-randomised trial; 468 women in labour with cervical dilatation less than 5 cm who were continuously monitored were compared with 346 women in whom CTG monitoring was commenced when cervix was more than 4 cm dilated. According to the trial report the cohort was divided into 2 groups 'according to cervical dilatation'
Manchester 1982	This quasi-RCT of 426 women at low risk was excluded because there were no reported data for the control group
North America 2000	Study design compared CTG with CTG plus continuous fetal pulse oximetry

CTG: cardiotocography
EFM: electronic fetal monitoring
RCT: randomised controlled trial

DATA AND ANALYSES

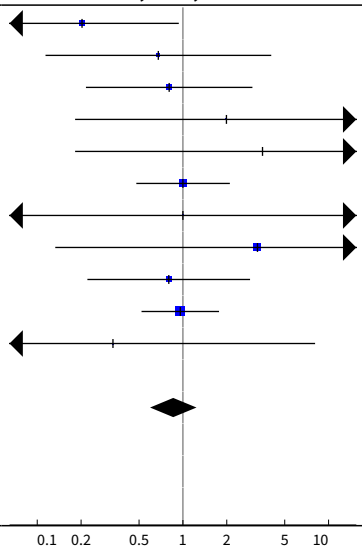
Comparison 1. Continuous CTG versus intermittent auscultation

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Perinatal mortality (main outcome)	11	33513	Risk Ratio (M-H, Fixed, 95% CI)	0.86 [0.59, 1.24]
2 Neonatal seizures (main outcome)	9	32386	Risk Ratio (M-H, Fixed, 95% CI)	0.50 [0.31, 0.80]
3 Cerebral palsy (main outcome)	2	13252	Risk Ratio (M-H, Random, 95% CI)	1.75 [0.84, 3.63]
4 Caesarean section (main outcome)	11	18861	Risk Ratio (M-H, Random, 95% CI)	1.63 [1.29, 2.07]
5 Instrumental vaginal birth (main outcome)	10	18615	Risk Ratio (M-H, Random, 95% CI)	1.15 [1.01, 1.33]
6 Cord blood acidosis (main outcome)	2	2494	Risk Ratio (M-H, Random, 95% CI)	0.92 [0.27, 3.11]
7 Any pharmacological analgesia (main outcome)	3	1677	Risk Ratio (M-H, Random, 95% CI)	0.98 [0.88, 1.09]
8 Hypoxic ischaemic encephalopathy	1	1428	Risk Ratio (M-H, Fixed, 95% CI)	0.46 [0.04, 5.03]
9 Neurodevelopmental disability at at least 12 months of age	1	173	Risk Ratio (M-H, Fixed, 95% CI)	3.88 [0.83, 18.17]
10 Apgar score < 7 at 5 minutes	6	4137	Risk Ratio (M-H, Fixed, 95% CI)	0.95 [0.71, 1.27]
11 Apgar score < 4 at 5 minutes	3	1919	Risk Ratio (M-H, Fixed, 95% CI)	1.80 [0.71, 4.59]

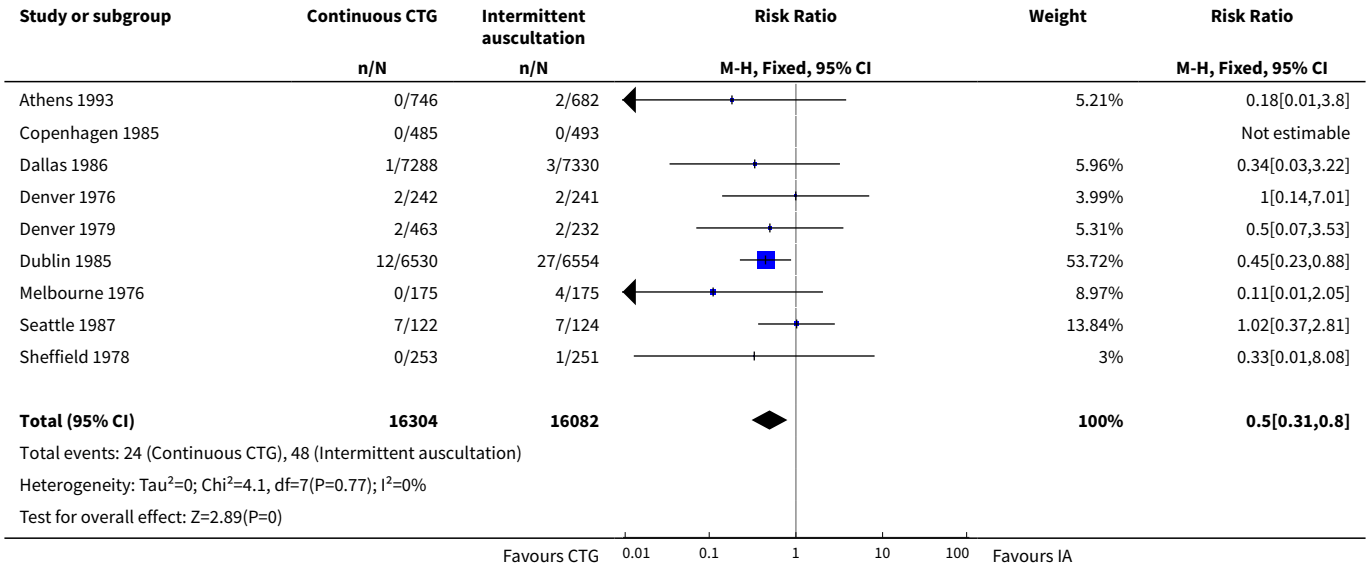
Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
12 Neonatal ICU admissions	10	33167	Risk Ratio (M-H, Random, 95% CI)	1.01 [0.86, 1.18]
13 Fetal blood sampling	2	13929	Risk Ratio (M-H, Fixed, 95% CI)	1.24 [1.05, 1.47]
14 Damage/infection from scalp electrode or scalp sampling	1	200	Risk Ratio (M-H, Fixed, 95% CI)	3.0 [0.12, 72.77]
15 Caesarean section for abnormal FHR pattern and/or acidosis	11	33379	Risk Ratio (M-H, Fixed, 95% CI)	2.38 [1.89, 3.01]
16 Instrumental vaginal birth for abnormal CTG or fetal acidosis	1	12964	Risk Ratio (M-H, Fixed, 95% CI)	2.54 [1.95, 3.31]
17 Spontaneous vaginal birth	11	18861	Risk Ratio (M-H, Random, 95% CI)	0.91 [0.86, 0.96]
18 Epidural analgesia	8	17630	Risk Ratio (M-H, Fixed, 95% CI)	1.00 [0.90, 1.12]
19 Oxytocin during 1st and/or 2nd stage of labour	5	3683	Risk Ratio (M-H, Random, 95% CI)	1.08 [0.86, 1.37]
20 Length of stay on NICU	1	206	Mean Difference (IV, Fixed, 95% CI)	0.20 [-1.17, 1.57]

Analysis 1.1. Comparison 1 Continuous CTG versus intermittent auscultation, Outcome 1 Perinatal mortality (main outcome).

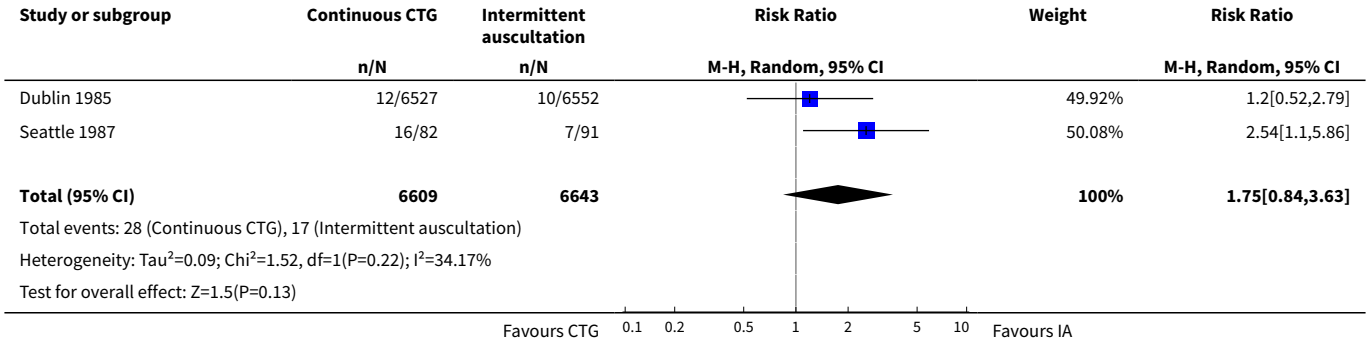
Study or subgroup	Continuous CTG n/N	Intermittent auscultation n/N	Risk Ratio M-H, Fixed, 95% CI	Weight	Risk Ratio M-H, Fixed, 95% CI
Athens 1993	2/746	9/682		15.98%	0.2[0.04,0.94]
Copenhagen 1985	2/485	3/493		5.06%	0.68[0.11,4.04]
Dallas 1986	4/7288	5/7330		8.47%	0.8[0.22,3]
Denver 1976	2/242	1/241		1.7%	1.99[0.18,21.82]
Denver 1979	3/463	0/232		1.13%	3.52[0.18,67.77]
Dublin 1985	14/6530	14/6554		23.75%	1[0.48,2.1]
Melbourne 1976	1/175	1/175		1.7%	1[0.06,15.86]
Melbourne 1981	1/445	0/482		0.82%	3.25[0.13,79.55]
Pakistan 1989	4/100	5/100		8.5%	0.8[0.22,2.89]
Seattle 1987	17/122	18/124		30.34%	0.96[0.52,1.77]
Sheffield 1978	0/253	1/251		2.56%	0.33[0.01,8.08]
Total (95% CI)	**16849**	**16664**		**100%**	**0.86[0.59,1.24]**
Total events: 50 (Continuous CTG), 57 (Intermittent auscultation)					
Heterogeneity: Tau^2=0; Chi^2=6.17, df=10(P=0.8); I^2=0%					
Test for overall effect: Z=0.82(P=0.41)					



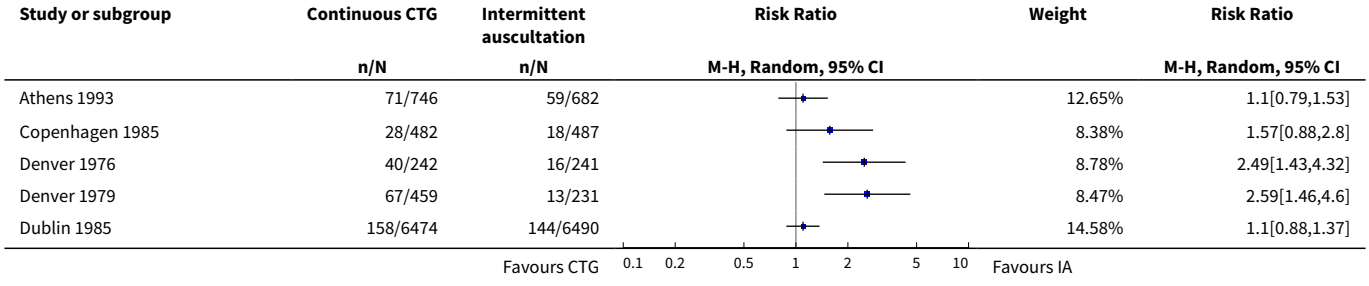
Analysis 1.2. Comparison 1 Continuous CTG versus intermittent auscultation, Outcome 2 Neonatal seizures (main outcome).

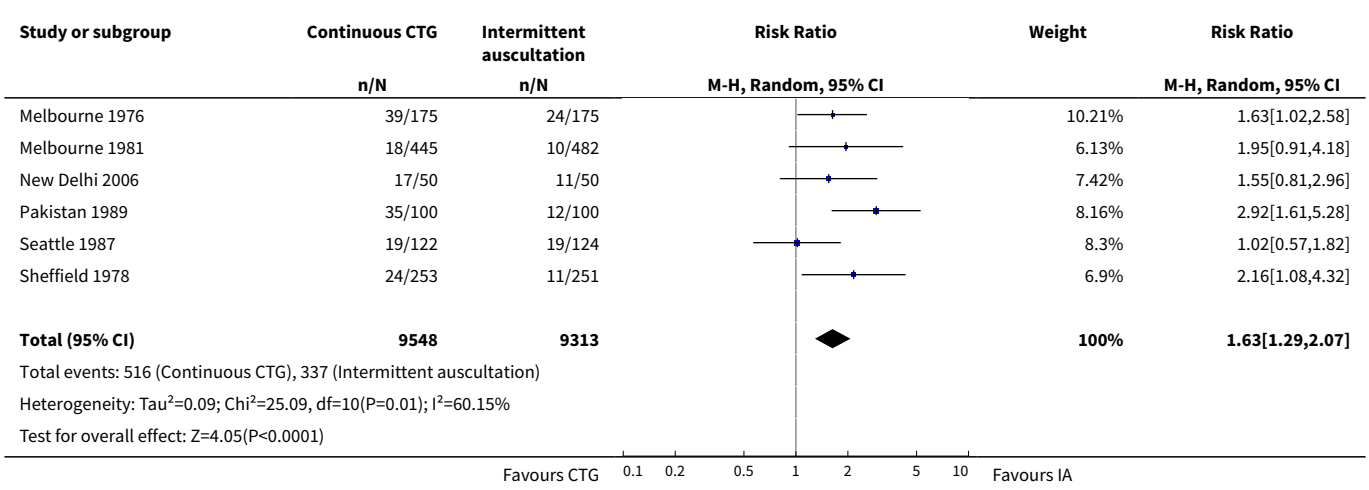


Analysis 1.3. Comparison 1 Continuous CTG versus intermittent auscultation, Outcome 3 Cerebral palsy (main outcome).

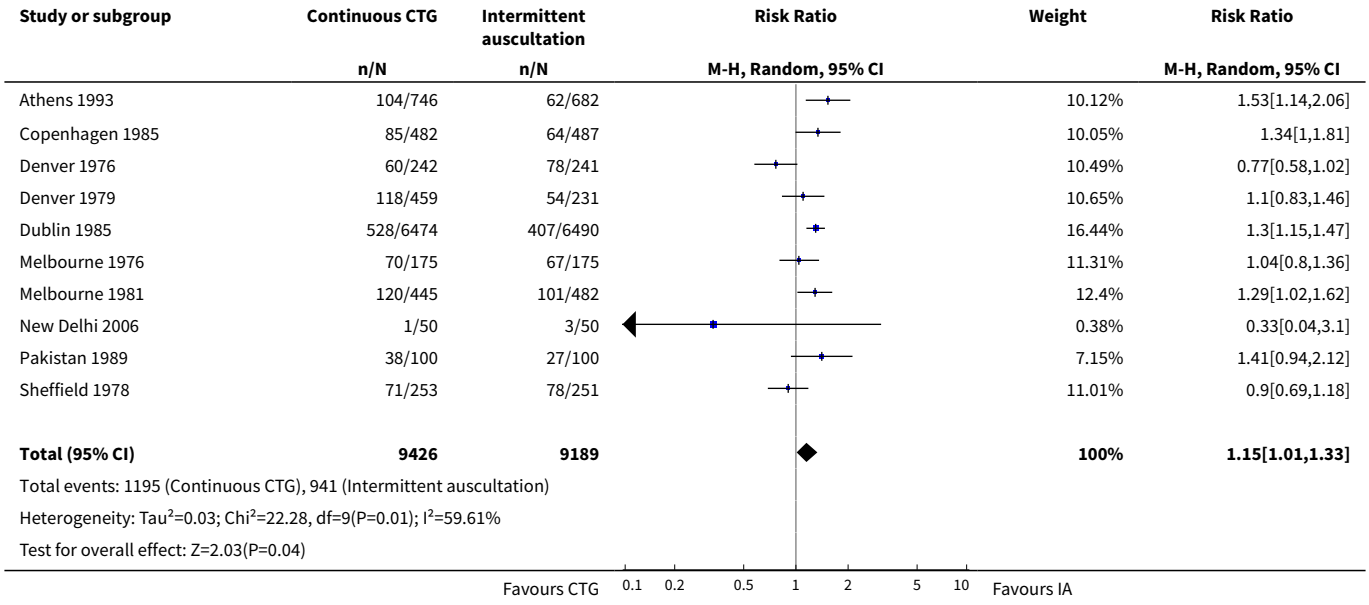


Analysis 1.4. Comparison 1 Continuous CTG versus intermittent auscultation, Outcome 4 Caesarean section (main outcome).

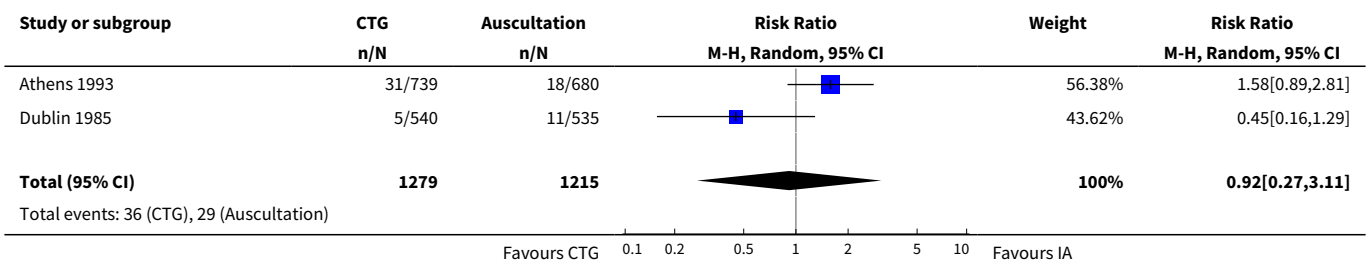




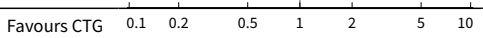
Analysis 1.5. Comparison 1 Continuous CTG versus intermittent auscultation, Outcome 5 Instrumental vaginal birth (main outcome).



Analysis 1.6. Comparison 1 Continuous CTG versus intermittent auscultation, Outcome 6 Cord blood acidosis (main outcome).

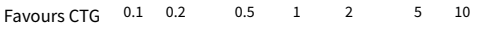


Study or subgroup	CTG n/N	Auscultation n/N	Risk Ratio M-H, Random, 95% CI	Weight	Risk Ratio M-H, Random, 95% CI
Heterogeneity: Tau²=0.61; Chi²=4.26, df=1(P=0.04); I²=76.53%					
Test for overall effect: Z=0.14(P=0.89)					



Analysis 1.7. Comparison 1 Continuous CTG versus intermittent auscultation, Outcome 7 Any pharmacological analgesia (main outcome).

Study or subgroup	CTG n/N	Auscultation n/N	Risk Ratio M-H, Random, 95% CI	Weight	Risk Ratio M-H, Random, 95% CI
Denver 1976	183/242	194/241		34.28%	0.94[0.85,1.03]
Denver 1979	418/459	199/231		41.36%	1.06[1,1.12]
Sheffield 1978	141/253	152/251		24.36%	0.92[0.79,1.07]
Total (95% CI)	**954**	**723**		**100%**	**0.98[0.88,1.09]**
Total events: 742 (CTG), 545 (Auscultation)					
Heterogeneity: Tau²=0.01; Chi²=7.2, df=2(P=0.03); I²=72.22%					
Test for overall effect: Z=0.35(P=0.73)					

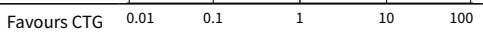


Analysis 1.8. Comparison 1 Continuous CTG versus intermittent auscultation, Outcome 8 Hypoxic ischaemic encephalopathy.

Study or subgroup	CTG n/N	Auscultation n/N	Risk Ratio M-H, Fixed, 95% CI	Weight	Risk Ratio M-H, Fixed, 95% CI
Athens 1993	1/746	2/682		100%	0.46[0.04,5.03]
Total (95% CI)	**746**	**682**		**100%**	**0.46[0.04,5.03]**
Total events: 1 (CTG), 2 (Auscultation)					
Heterogeneity: Not applicable					
Test for overall effect: Z=0.64(P=0.52)					

Analysis 1.9. Comparison 1 Continuous CTG versus intermittent auscultation, Outcome 9 Neurodevelopmental disability at at least 12 months of age.

Study or subgroup	CTG n/N	Auscultation n/N	Risk Ratio M-H, Fixed, 95% CI	Weight	Risk Ratio M-H, Fixed, 95% CI
Seattle 1987	7/82	2/91		100%	3.88[0.83,18.17]
Total (95% CI)	**82**	**91**		**100%**	**3.88[0.83,18.17]**
Total events: 7 (CTG), 2 (Auscultation)					
Heterogeneity: Not applicable					
Test for overall effect: Z=1.72(P=0.08)					



Analysis 1.10. Comparison 1 Continuous CTG versus intermittent auscultation, Outcome 10 Apgar score < 7 at 5 minutes.

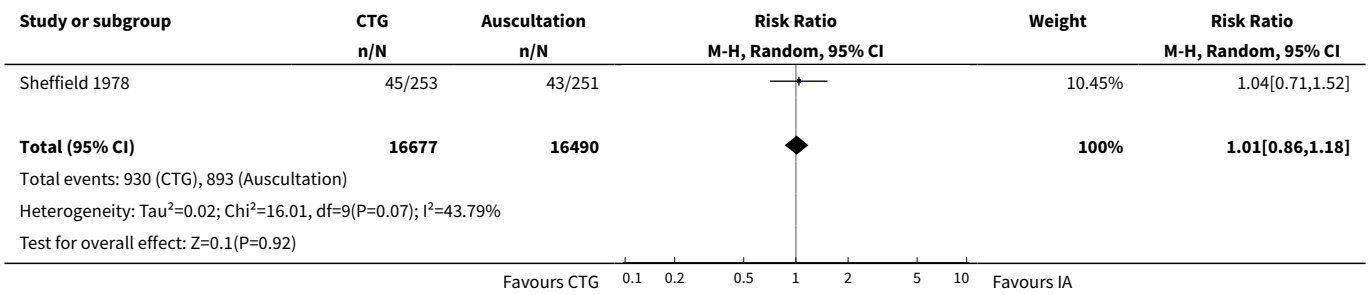
Study or subgroup	CTG n/N	Auscultation n/N	Risk Ratio M-H, Fixed, 95% CI	Weight	Risk Ratio M-H, Fixed, 95% CI
Athens 1993	31/746	26/682		31.75%	1.09[0.65,1.82]
Copenhagen 1985	0/485	2/493		2.9%	0.2[0.01,4.22]
Melbourne 1981	39/445	40/482		44.89%	1.06[0.69,1.61]
New Delhi 2006	1/50	3/50		3.51%	0.33[0.04,3.1]
Pakistan 1989	9/100	12/100		14.03%	0.75[0.33,1.7]
Sheffield 1978	0/253	2/251		2.93%	0.2[0.01,4.11]
Total (95% CI)	**2079**	**2058**		**100%**	**0.95[0.71,1.27]**
Total events: 80 (CTG), 85 (Auscultation)					
Heterogeneity: Tau^2=0; Chi^2=3.71, df=5(P=0.59); I^2=0%					
Test for overall effect: Z=0.35(P=0.72)					

Analysis 1.11. Comparison 1 Continuous CTG versus intermittent auscultation, Outcome 11 Apgar score < 4 at 5 minutes.

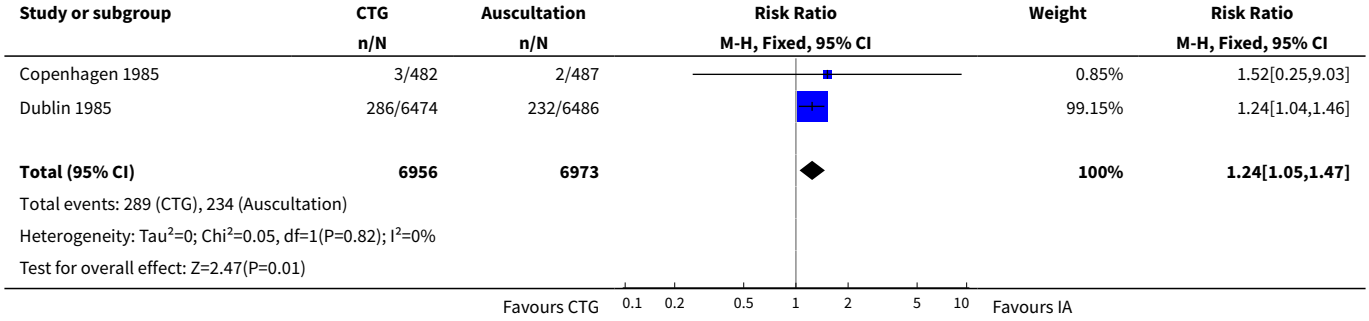
Study or subgroup	CTG n/N	Auscultation n/N	Risk Ratio M-H, Fixed, 95% CI	Weight	Risk Ratio M-H, Fixed, 95% CI
Copenhagen 1985	0/485	1/493		21.92%	0.34[0.01,8.3]
Denver 1979	4/463	1/232		19.63%	2[0.23,17.83]
Seattle 1987	9/122	4/124		58.45%	2.29[0.72,7.23]
Total (95% CI)	**1070**	**849**		**100%**	**1.8[0.71,4.59]**
Total events: 13 (CTG), 6 (Auscultation)					
Heterogeneity: Tau^2=0; Chi^2=1.22, df=2(P=0.54); I^2=0%					
Test for overall effect: Z=1.24(P=0.21)					

Analysis 1.12. Comparison 1 Continuous CTG versus intermittent auscultation, Outcome 12 Neonatal ICU admissions.

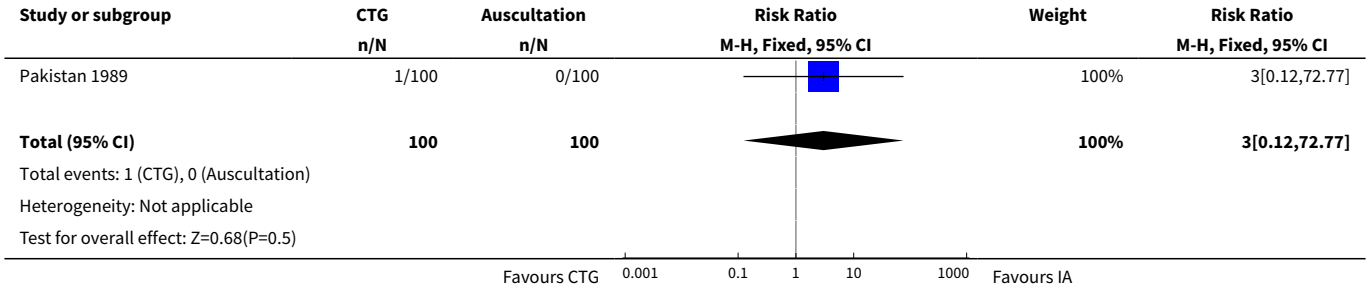
Study or subgroup	CTG n/N	Auscultation n/N	Risk Ratio M-H, Random, 95% CI	Weight	Risk Ratio M-H, Random, 95% CI
Athens 1993	104/746	102/682		16.03%	0.93[0.72,1.2]
Copenhagen 1985	51/485	49/493		10.74%	1.06[0.73,1.53]
Dallas 1986	25/7288	17/7330		5.19%	1.48[0.8,2.74]
Denver 1976	35/242	28/241		8%	1.24[0.78,1.98]
Denver 1979	52/463	29/232		9%	0.9[0.59,1.38]
Dublin 1985	547/6530	543/6554		24.22%	1.01[0.9,1.13]
Melbourne 1976	11/175	30/175		4.64%	0.37[0.19,0.71]
Melbourne 1981	59/445	48/482		11.21%	1.33[0.93,1.91]
New Delhi 2006	1/50	4/50		0.51%	0.25[0.03,2.16]



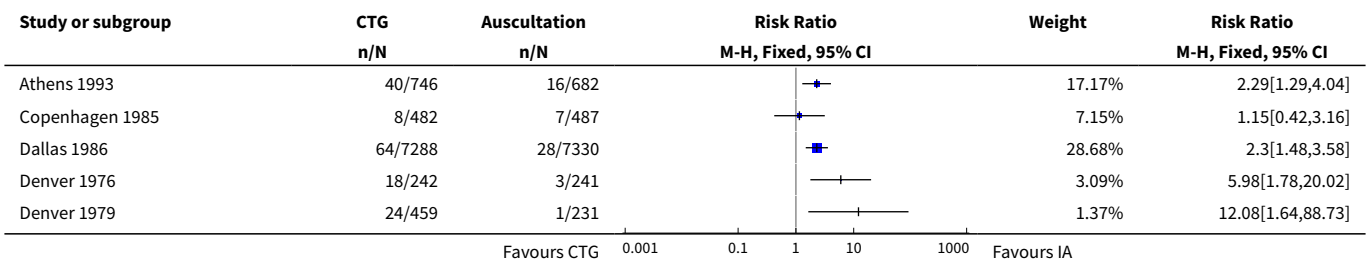
Analysis 1.13. Comparison 1 Continuous CTG versus intermittent auscultation, Outcome 13 Fetal blood sampling.

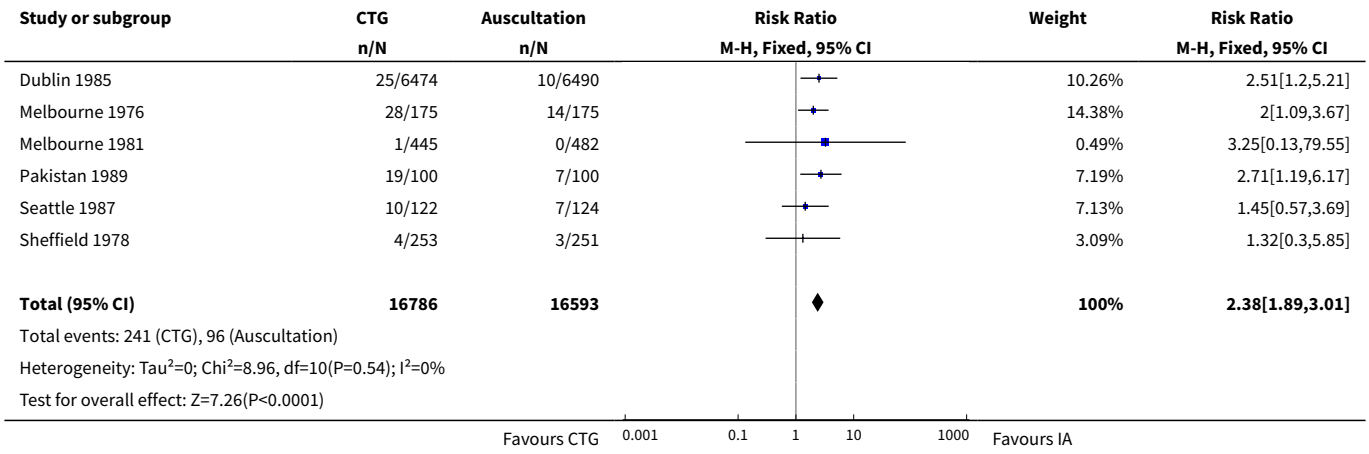


Analysis 1.14. Comparison 1 Continuous CTG versus intermittent auscultation, Outcome 14 Damage/infection from scalp electrode or scalp sampling.

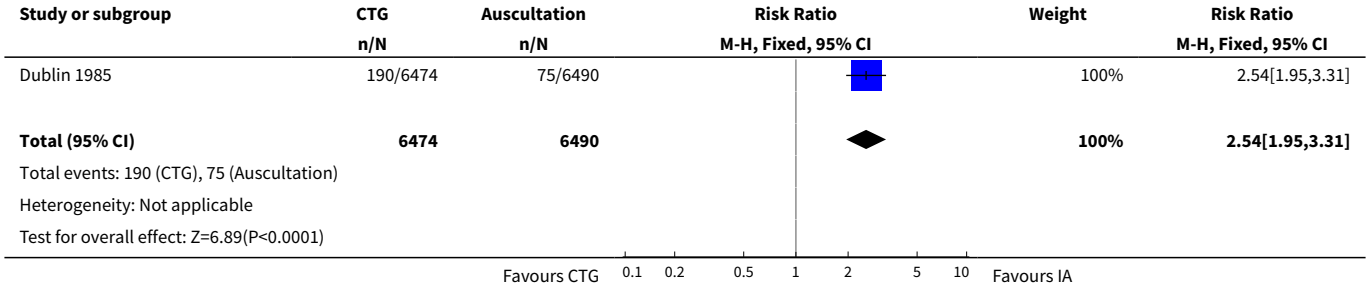


Analysis 1.15. Comparison 1 Continuous CTG versus intermittent auscultation, Outcome 15 Caesarean section for abnormal FHR pattern and/or acidosis.

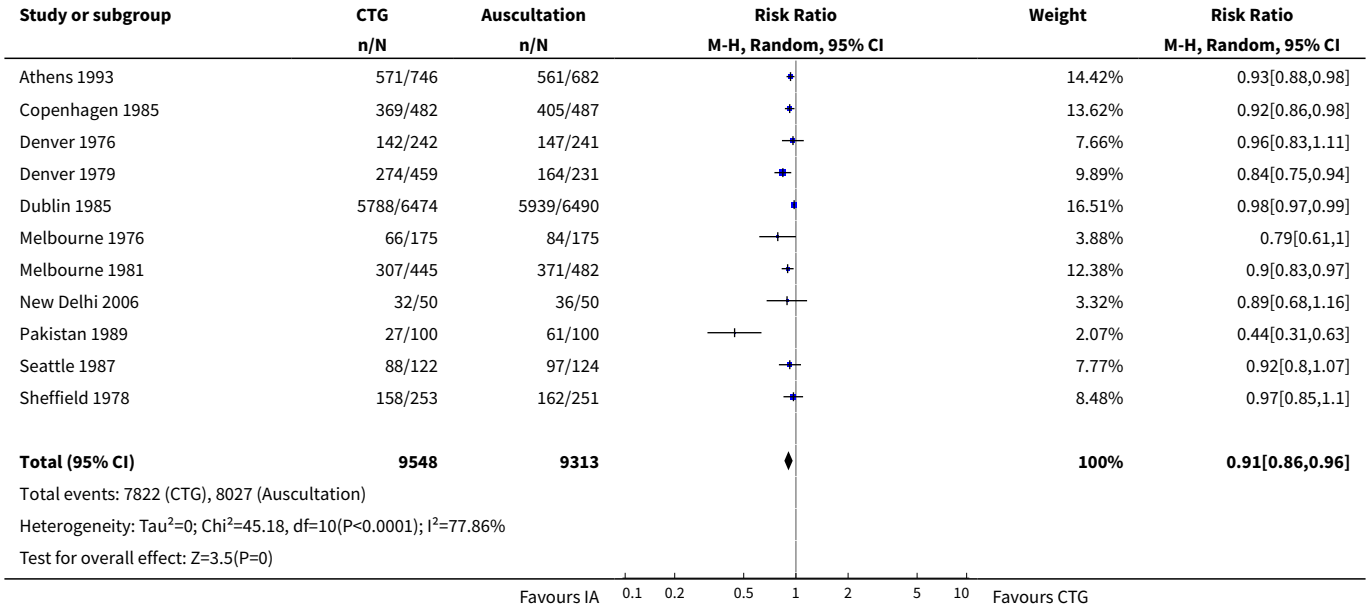




Analysis 1.16. Comparison 1 Continuous CTG versus intermittent auscultation, Outcome 16 Instrumental vaginal birth for abnormal CTG or fetal acidosis.

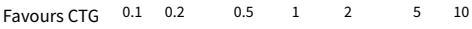


Analysis 1.17. Comparison 1 Continuous CTG versus intermittent auscultation, Outcome 17 Spontaneous vaginal birth.



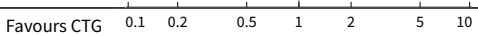
Analysis 1.18. Comparison 1 Continuous CTG versus intermittent auscultation, Outcome 18 Epidural analgesia.

Study or subgroup	CTG n/N	Auscultation n/N	Risk Ratio M-H, Fixed, 95% CI	Weight	Risk Ratio M-H, Fixed, 95% CI
Athens 1993	2/746	2/682		0.38%	0.91[0.13,6.47]
Copenhagen 1985	51/482	34/487		6.13%	1.52[1,2.3]
Denver 1976	51/242	69/241		12.53%	0.74[0.54,1.01]
Denver 1979	93/459	48/231		11.58%	0.98[0.71,1.33]
Dublin 1985	194/6474	195/6486		35.31%	1[0.82,1.21]
Melbourne 1976	50/175	43/175		7.79%	1.16[0.82,1.65]
Seattle 1987	56/122	53/124		9.53%	1.07[0.81,1.42]
Sheffield 1978	87/253	92/251		16.74%	0.94[0.74,1.19]
Total (95% CI)	**8953**	**8677**		**100%**	**1[0.9,1.12]**
Total events: 584 (CTG), 536 (Auscultation)					
Heterogeneity: Tau^2=0; Chi^2=8.77, df=7(P=0.27); I^2=20.22%					
Test for overall effect: Z=0.07(P=0.95)					



Analysis 1.19. Comparison 1 Continuous CTG versus intermittent auscultation, Outcome 19 Oxytocin during 1st and/or 2nd stage of labour.

Study or subgroup	CTG n/N	Auscultation n/N	Risk Ratio M-H, Random, 95% CI	Weight	Risk Ratio M-H, Random, 95% CI
Athens 1993	508/746	308/682		22.69%	1.51[1.37,1.66]
Copenhagen 1985	194/482	195/487		21.42%	1.01[0.86,1.17]
Denver 1979	139/459	64/231		18.58%	1.09[0.85,1.4]
Melbourne 1976	109/175	110/175		21.2%	0.99[0.84,1.17]
Seattle 1987	41/122	50/124		16.1%	0.83[0.6,1.16]
Total (95% CI)	**1984**	**1699**		**100%**	**1.08[0.86,1.37]**
Total events: 991 (CTG), 727 (Auscultation)					
Heterogeneity: Tau^2=0.06; Chi^2=37.02, df=4(P<0.0001); I^2=89.2%					
Test for overall effect: Z=0.67(P=0.51)					



Analysis 1.20. Comparison 1 Continuous CTG versus intermittent auscultation, Outcome 20 Length of stay on NICU.

Study or subgroup	CTG N	CTG Mean(SD)	Auscultation N	Auscultation Mean(SD)	Mean Difference Fixed, 95% CI	Weight	Mean Difference Fixed, 95% CI
Athens 1993	104	5.2 (5)	102	5 (5)		100%	0.2[-1.17,1.57]
Total ***	**104**		**102**			**100%**	**0.2[-1.17,1.57]**
Heterogeneity: Not applicable							
Test for overall effect: Z=0.29(P=0.77)							

Comparison 2. Continuous CTG versus IA (pregnancy risk status - high/low)

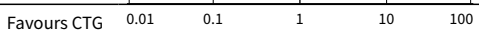
Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Perinatal mortality	11	33513	Risk Ratio (M-H, Fixed, 95% CI)	0.86 [0.59, 1.24]
1.1 High risk	5	1974	Risk Ratio (M-H, Fixed, 95% CI)	1.04 [0.62, 1.74]
1.2 Low risk	3	16049	Risk Ratio (M-H, Fixed, 95% CI)	0.87 [0.29, 2.58]
1.3 Risk status - mixed or not specified	3	15490	Risk Ratio (M-H, Fixed, 95% CI)	0.68 [0.38, 1.24]
2 Neonatal seizures	9	32386	Risk Ratio (M-H, Fixed, 95% CI)	0.50 [0.31, 0.80]
2.1 High risk	5	4805	Risk Ratio (M-H, Fixed, 95% CI)	0.67 [0.36, 1.24]
2.2 Low risk	3	25175	Risk Ratio (M-H, Fixed, 95% CI)	0.36 [0.16, 0.79]
2.3 Risk status - mixed or not specified	2	2406	Risk Ratio (M-H, Fixed, 95% CI)	0.18 [0.01, 3.80]
3 Cerebral palsy	2	13252	Risk Ratio (M-H, Fixed, 95% CI)	1.74 [0.97, 3.11]
3.1 High risk	1	173	Risk Ratio (M-H, Fixed, 95% CI)	2.54 [1.10, 5.86]
3.2 Low risk	0	0	Risk Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]
3.3 Risk status - mixed or not specified	1	13079	Risk Ratio (M-H, Fixed, 95% CI)	1.20 [0.52, 2.79]
4 Caesarean section	11	18861	Risk Ratio (M-H, Random, 95% CI)	1.63 [1.29, 2.07]
4.1 High risk	6	2069	Risk Ratio (M-H, Random, 95% CI)	1.91 [1.39, 2.61]
4.2 Low risk	2	1431	Risk Ratio (M-H, Random, 95% CI)	2.06 [1.24, 3.45]
4.3 Risk status - mixed or not specified	3	15361	Risk Ratio (M-H, Random, 95% CI)	1.14 [0.95, 1.36]
5 Instrumental vaginal birth	10	18615	Risk Ratio (M-H, Random, 95% CI)	1.15 [1.01, 1.33]
5.1 High risk	5	1823	Risk Ratio (M-H, Random, 95% CI)	1.02 [0.82, 1.27]
5.2 Low risk	2	1431	Risk Ratio (M-H, Random, 95% CI)	1.09 [0.77, 1.54]
5.3 Risk status - mixed or not specified	3	15361	Risk Ratio (M-H, Random, 95% CI)	1.33 [1.20, 1.49]
6 Cord blood acidosis	2	2494	Risk Ratio (M-H, Fixed, 95% CI)	1.16 [0.72, 1.89]
6.1 High risk	0	0	Risk Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]
6.2 Low risk	0	0	Risk Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
6.3 Risk status - mixed or not specified	2	2494	Risk Ratio (M-H, Fixed, 95% CI)	1.16 [0.72, 1.89]
7 Any pharmacological analgesia	3	1677	Risk Ratio (M-H, Fixed, 95% CI)	0.99 [0.93, 1.04]
7.1 High risk	2	1173	Risk Ratio (M-H, Fixed, 95% CI)	1.01 [0.96, 1.06]
7.2 Low risk	1	504	Risk Ratio (M-H, Fixed, 95% CI)	0.92 [0.79, 1.07]
7.3 Risk status - mixed or not specified	0	0	Risk Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]

Analysis 2.1. Comparison 2 Continuous CTG versus IA (pregnancy risk status - high/low), Outcome 1 Perinatal mortality.

Study or subgroup	Continuous CTG n/N	IA n/N	Risk Ratio M-H, Fixed, 95% CI	Weight	Risk Ratio M-H, Fixed, 95% CI
2.1.1 High risk					
Denver 1976	2/242	1/241		1.7%	1.99[0.18,21.82]
Denver 1979	3/463	0/232		1.13%	3.52[0.18,67.77]
Melbourne 1976	1/175	1/175		1.7%	1[0.06,15.86]
Pakistan 1989	4/100	5/100		8.5%	0.8[0.22,2.89]
Seattle 1987	17/122	18/124		30.34%	0.96[0.52,1.77]
Subtotal (95% CI)	**1102**	**872**		**43.37%**	**1.04[0.62,1.74]**
Total events: 27 (Continuous CTG), 25 (IA)					
Heterogeneity: Tau^2=0; Chi^2=1.16, df=4(P=0.89); I^2=0%					
Test for overall effect: Z=0.14(P=0.89)					
2.1.2 Low risk					
Dallas 1986	4/7288	5/7330		8.47%	0.8[0.22,3]
Melbourne 1981	1/445	0/482		0.82%	3.25[0.13,79.55]
Sheffield 1978	0/253	1/251		2.56%	0.33[0.01,8.08]
Subtotal (95% CI)	**7986**	**8063**		**11.85%**	**0.87[0.29,2.58]**
Total events: 5 (Continuous CTG), 6 (IA)					
Heterogeneity: Tau^2=0; Chi^2=1.02, df=2(P=0.6); I^2=0%					
Test for overall effect: Z=0.25(P=0.8)					
2.1.3 Risk status - mixed or not specified					
Athens 1993	2/746	9/682		15.98%	0.2[0.04,0.94]
Copenhagen 1985	2/485	3/493		5.06%	0.68[0.11,4.04]
Dublin 1985	14/6530	14/6554		23.75%	1[0.48,2.1]
Subtotal (95% CI)	**7761**	**7729**		**44.78%**	**0.68[0.38,1.24]**
Total events: 18 (Continuous CTG), 26 (IA)					
Heterogeneity: Tau^2=0; Chi^2=3.46, df=2(P=0.18); I^2=42.2%					
Test for overall effect: Z=1.26(P=0.21)					
Total (95% CI)	**16849**	**16664**		**100%**	**0.86[0.59,1.24]**
Total events: 50 (Continuous CTG), 57 (IA)					

Study or subgroup	Continuous CTG n/N	IA n/N	Risk Ratio M-H, Fixed, 95% CI	Weight	Risk Ratio M-H, Fixed, 95% CI
Heterogeneity: Tau²=0; Chi²=6.17, df=10(P=0.8); I²=0%					
Test for overall effect: Z=0.82(P=0.41)					
Test for subgroup differences: Chi²=1.09, df=1 (P=0.58), I²=0%					

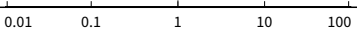


Analysis 2.2. Comparison 2 Continuous CTG versus IA (pregnancy risk status - high/low), Outcome 2 Neonatal seizures.

Study or subgroup	Continuous CTG n/N	IA n/N	Risk Ratio M-H, Fixed, 95% CI	Weight	Risk Ratio M-H, Fixed, 95% CI
2.2.1 High risk					
Denver 1976	2/242	2/241		4%	1[0.14,7.01]
Denver 1979	2/463	2/232		5.31%	0.5[0.07,3.53]
Dublin 1985	5/1492	8/1539		15.71%	0.64[0.21,1.97]
Melbourne 1976	0/175	4/175		8.97%	0.11[0.01,2.05]
Seattle 1987	7/122	7/124		13.85%	1.02[0.37,2.81]
Subtotal (95% CI)	**2494**	**2311**		**47.84%**	**0.67[0.36,1.24]**
Total events: 16 (Continuous CTG), 23 (IA)					
Heterogeneity: Tau²=0; Chi²=2.36, df=4(P=0.67); I²=0%					
Test for overall effect: Z=1.28(P=0.2)					
2.2.2 Low risk					
Dallas 1986	1/7288	3/7330		5.97%	0.34[0.03,3.22]
Dublin 1985	7/5038	19/5015		37.98%	0.37[0.15,0.87]
Sheffield 1978	0/253	1/251		3%	0.33[0.01,8.08]
Subtotal (95% CI)	**12579**	**12596**		**46.95%**	**0.36[0.16,0.79]**
Total events: 8 (Continuous CTG), 23 (IA)					
Heterogeneity: Tau²=0; Chi²=0.01, df=2(P=1); I²=0%					
Test for overall effect: Z=2.55(P=0.01)					
2.2.3 Risk status - mixed or not specified					
Athens 1993	0/746	2/682		5.21%	0.18[0.01,3.8]
Copenhagen 1985	0/485	0/493			Not estimable
Subtotal (95% CI)	**1231**	**1175**		**5.21%**	**0.18[0.01,3.8]**
Total events: 0 (Continuous CTG), 2 (IA)					
Heterogeneity: Not applicable					
Test for overall effect: Z=1.1(P=0.27)					
Total (95% CI)	**16304**	**16082**		**100%**	**0.5[0.31,0.8]**
Total events: 24 (Continuous CTG), 48 (IA)					
Heterogeneity: Tau²=0; Chi²=4.68, df=8(P=0.79); I²=0%					
Test for overall effect: Z=2.88(P=0)					
Test for subgroup differences: Chi²=1.89, df=1 (P=0.39), I²=0%					

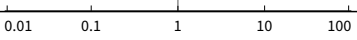
Analysis 2.3. Comparison 2 Continuous CTG versus IA (pregnancy risk status - high/low), Outcome 3 Cerebral palsy.

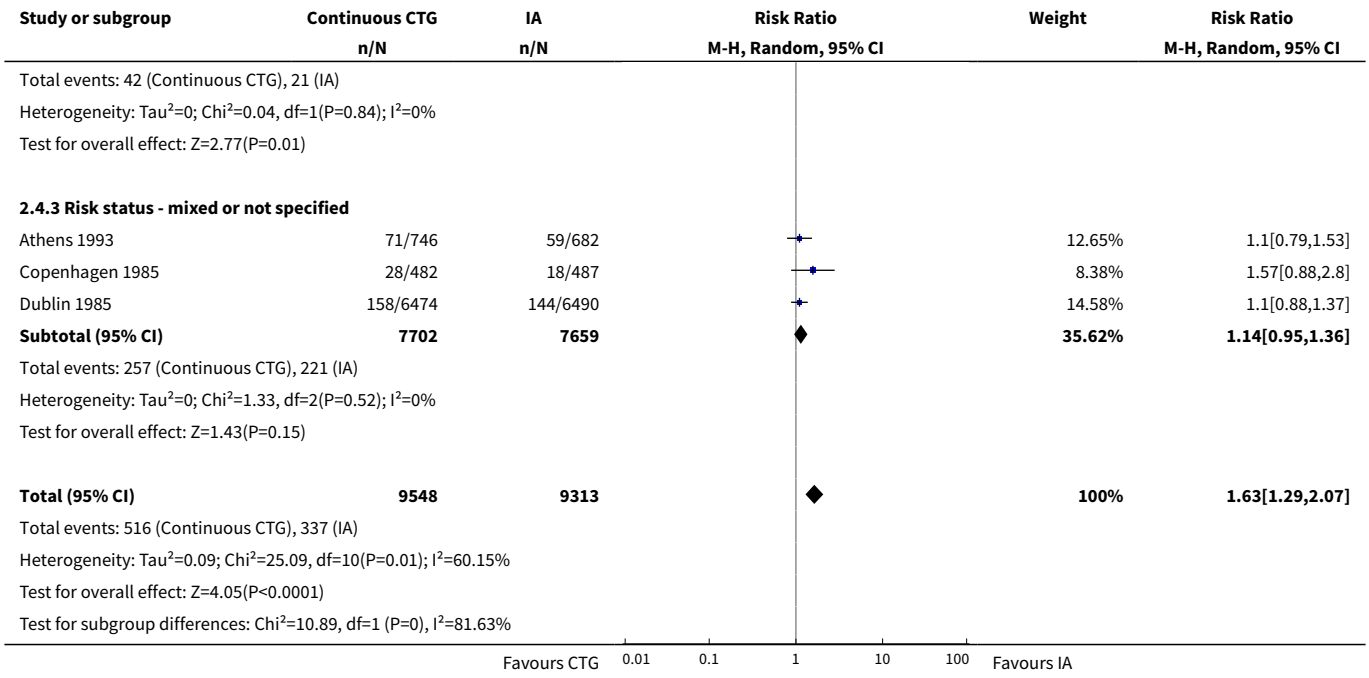
Study or subgroup	Continuous CTG n/N	IA n/N	Risk Ratio M-H, Fixed, 95% CI	Weight	Risk Ratio M-H, Fixed, 95% CI
2.3.1 High risk					
Seattle 1987	16/82	7/91		39.93%	2.54[1.1,5.86]
Subtotal (95% CI)	**82**	**91**		**39.93%**	**2.54[1.1,5.86]**
Total events: 16 (Continuous CTG), 7 (IA)					
Heterogeneity: Not applicable					
Test for overall effect: Z=2.18(P=0.03)					
2.3.2 Low risk					
Subtotal (95% CI)	**0**	**0**			**Not estimable**
Total events: 0 (Continuous CTG), 0 (IA)					
Heterogeneity: Not applicable					
Test for overall effect: Not applicable					
2.3.3 Risk status - mixed or not specified					
Dublin 1985	12/6527	10/6552		60.07%	1.2[0.52,2.79]
Subtotal (95% CI)	**6527**	**6552**		**60.07%**	**1.2[0.52,2.79]**
Total events: 12 (Continuous CTG), 10 (IA)					
Heterogeneity: Not applicable					
Test for overall effect: Z=0.44(P=0.66)					
Total (95% CI)	**6609**	**6643**		**100%**	**1.74[0.97,3.11]**
Total events: 28 (Continuous CTG), 17 (IA)					
Heterogeneity: Tau^2=0; Chi^2=1.52, df=1(P=0.22); I^2=34.17%					
Test for overall effect: Z=1.86(P=0.06)					
Test for subgroup differences: Chi^2=1.52, df=1 (P=0.22), I^2=34.14%					



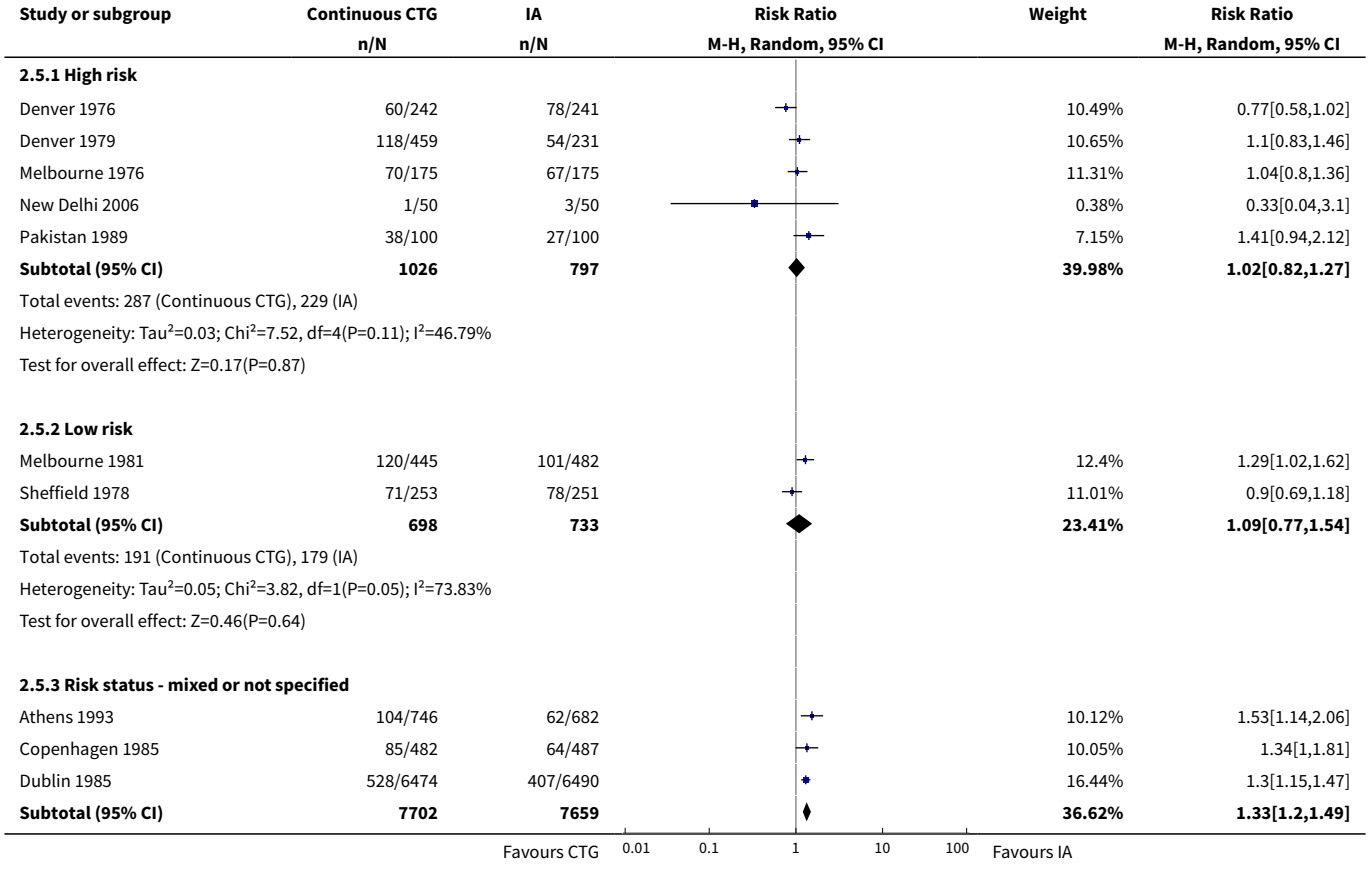
Analysis 2.4. Comparison 2 Continuous CTG versus IA (pregnancy risk status - high/low), Outcome 4 Caesarean section.

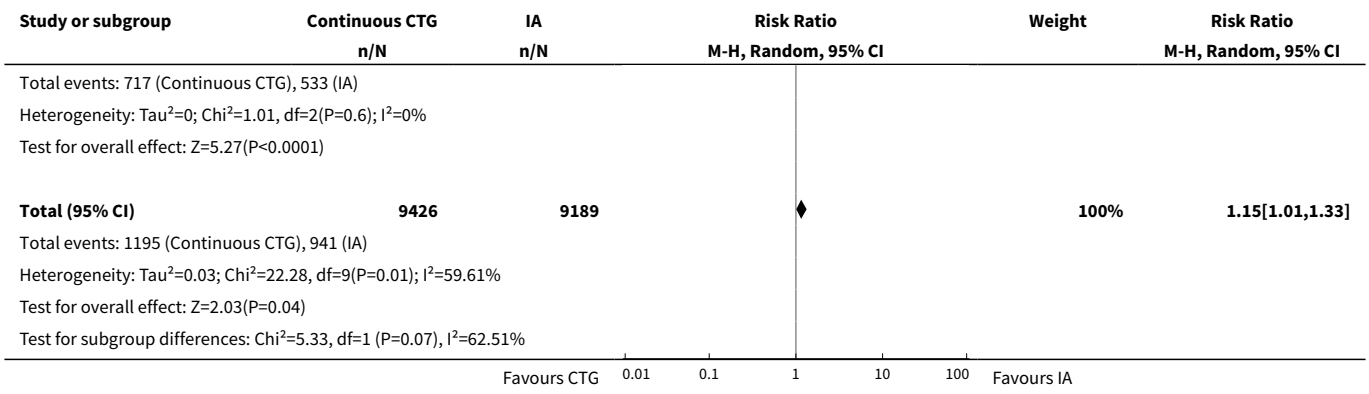
Study or subgroup	Continuous CTG n/N	IA n/N	Risk Ratio M-H, Random, 95% CI	Weight	Risk Ratio M-H, Random, 95% CI
2.4.1 High risk					
Denver 1976	40/242	16/241		8.78%	2.49[1.43,4.32]
Denver 1979	67/459	13/231		8.47%	2.59[1.46,4.6]
Melbourne 1976	39/175	24/175		10.21%	1.63[1.02,2.58]
New Delhi 2006	17/50	11/50		7.42%	1.55[0.81,2.96]
Pakistan 1989	35/100	12/100		8.16%	2.92[1.61,5.28]
Seattle 1987	19/122	19/124		8.3%	1.02[0.57,1.82]
Subtotal (95% CI)	**1148**	**921**		**51.35%**	**1.91[1.39,2.61]**
Total events: 217 (Continuous CTG), 95 (IA)					
Heterogeneity: Tau^2=0.07; Chi^2=9.36, df=5(P=0.1); I^2=46.6%					
Test for overall effect: Z=4.01(P<0.0001)					
2.4.2 Low risk					
Melbourne 1981	18/445	10/482		6.13%	1.95[0.91,4.18]
Sheffield 1978	24/253	11/251		6.9%	2.16[1.08,4.32]
Subtotal (95% CI)	**698**	**733**		**13.03%**	**2.06[1.24,3.45]**



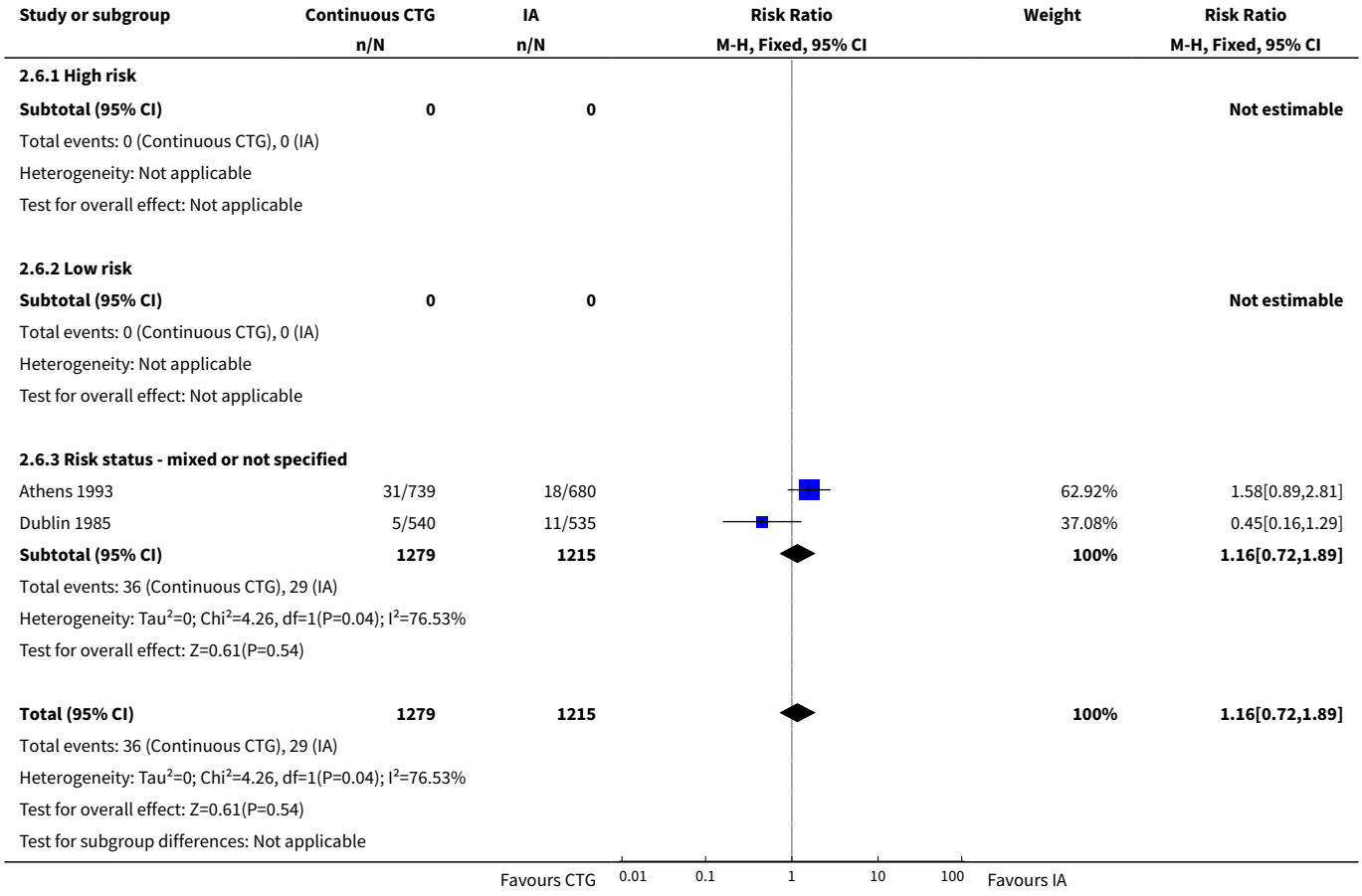


Analysis 2.5. Comparison 2 Continuous CTG versus IA (pregnancy risk status - high/low), Outcome 5 Instrumental vaginal birth.

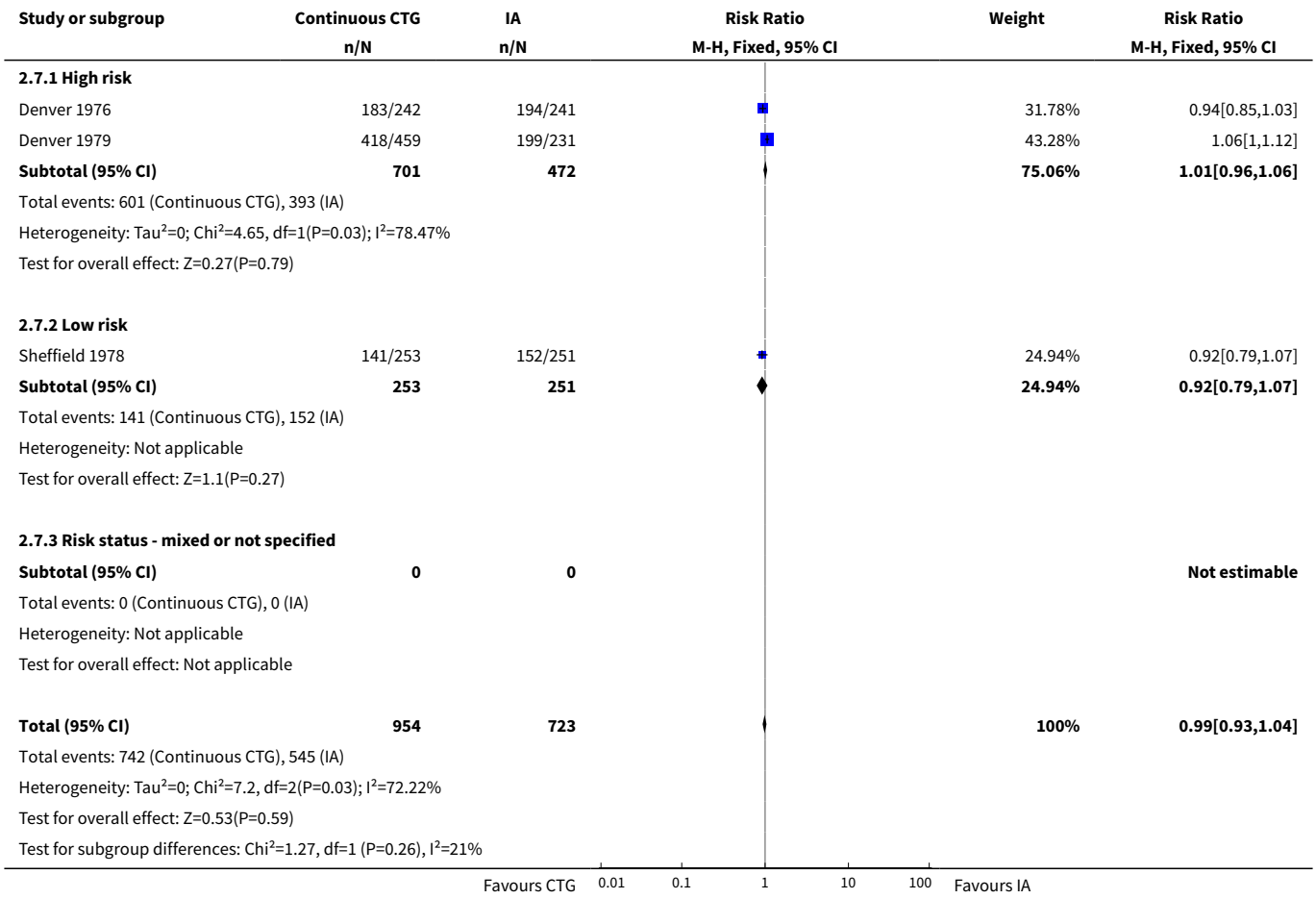




Analysis 2.6. Comparison 2 Continuous CTG versus IA (pregnancy risk status - high/low), Outcome 6 Cord blood acidosis.



Analysis 2.7. Comparison 2 Continuous CTG versus IA (pregnancy risk status - high/low), Outcome 7 Any pharmacological analgesia.



Comparison 3. Continuous CTG versus IA (onset of labour - spontaneous/induced)

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Perinatal mortality	11	33513	Risk Ratio (M-H, Fixed, 95% CI)	0.86 [0.59, 1.24]
1.1 Spontaneous labour	0	0	Risk Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]
1.2 Induction of labour	0	0	Risk Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]
1.3 Onset of labour - not specified	11	33513	Risk Ratio (M-H, Fixed, 95% CI)	0.86 [0.59, 1.24]
2 Neonatal seizures	9	32386	Risk Ratio (M-H, Fixed, 95% CI)	0.50 [0.31, 0.80]
2.1 Spontaneous labour	0	0	Risk Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]
2.2 Induction of labour	0	0	Risk Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]

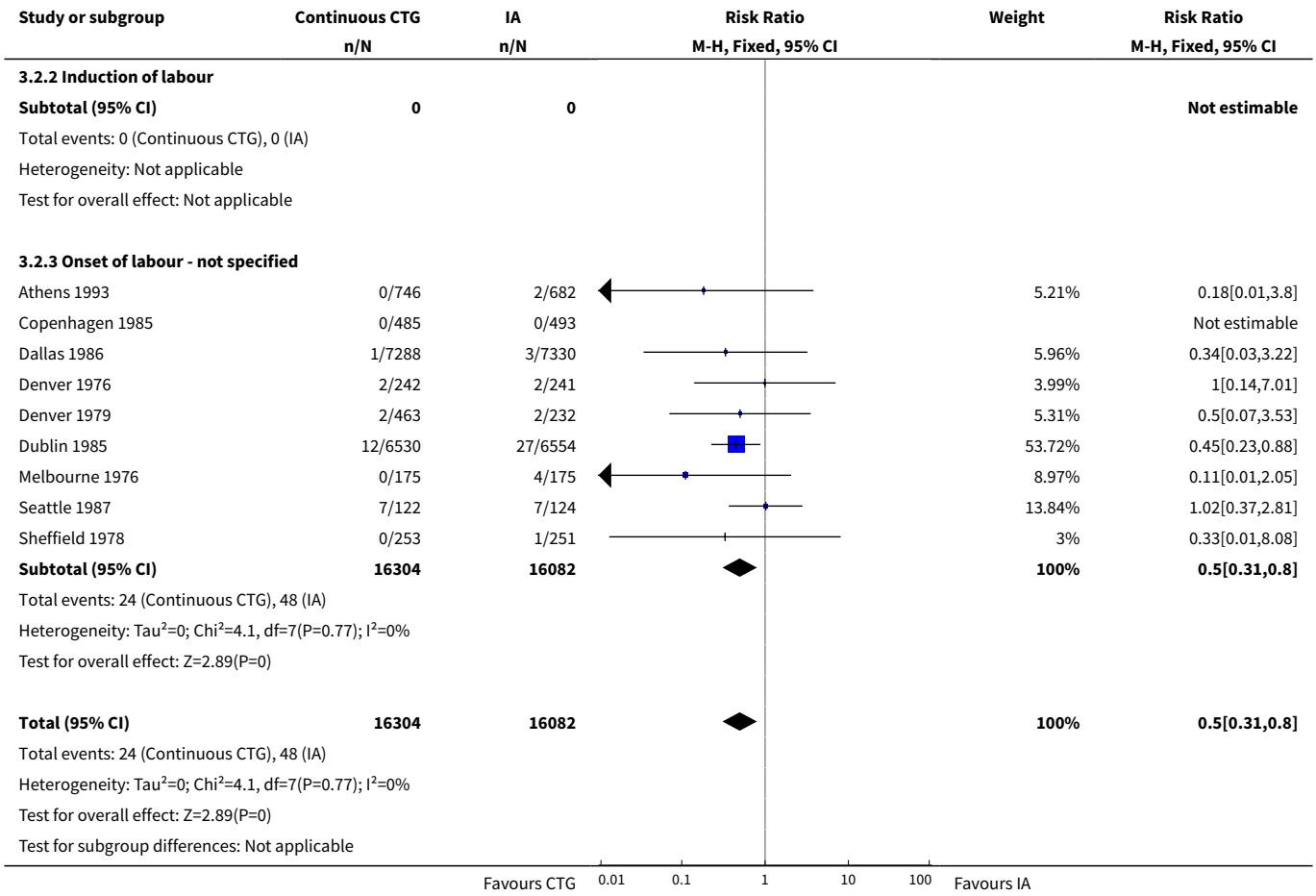
Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
2.3 Onset of labour - not specified	9	32386	Risk Ratio (M-H, Fixed, 95% CI)	0.50 [0.31, 0.80]
3 Cerebral palsy	2	13252	Risk Ratio (M-H, Fixed, 95% CI)	1.74 [0.97, 3.11]
3.1 Spontaneous labour	0	0	Risk Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]
3.2 Induction of labour	0	0	Risk Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]
3.3 Onset of labour - not specified	2	13252	Risk Ratio (M-H, Fixed, 95% CI)	1.74 [0.97, 3.11]
4 Caesarean section	11	18861	Risk Ratio (M-H, Fixed, 95% CI)	1.43 [1.25, 1.64]
4.1 Spontaneous labour	0	0	Risk Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]
4.2 Induction of labour	0	0	Risk Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]
4.3 Onset of labour - not specified	11	18861	Risk Ratio (M-H, Fixed, 95% CI)	1.43 [1.25, 1.64]
5 Instrumental vaginal birth	10	18615	Risk Ratio (M-H, Fixed, 95% CI)	1.21 [1.12, 1.31]
5.1 Spontaneous labour	0	0	Risk Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]
5.2 Induction of labour	0	0	Risk Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]
5.3 Onset of labour - not specified	10	18615	Risk Ratio (M-H, Fixed, 95% CI)	1.21 [1.12, 1.31]
6 Cord blood acidosis	2	2494	Risk Ratio (M-H, Fixed, 95% CI)	1.16 [0.72, 1.89]
6.1 Spontaneous labour	0	0	Risk Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]
6.2 Induction of labour	0	0	Risk Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]
6.3 Onset of labour - not specified	2	2494	Risk Ratio (M-H, Fixed, 95% CI)	1.16 [0.72, 1.89]
7 Any pharmacological analgesia	3	1677	Risk Ratio (M-H, Fixed, 95% CI)	0.99 [0.93, 1.04]
7.1 Spontaneous labour	0	0	Risk Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]
7.2 Induction of labour	0	0	Risk Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]
7.3 Onset of labour - not specified	3	1677	Risk Ratio (M-H, Fixed, 95% CI)	0.99 [0.93, 1.04]

Analysis 3.1. Comparison 3 Continuous CTG versus IA (onset of labour - spontaneous/induced), Outcome 1 Perinatal mortality.

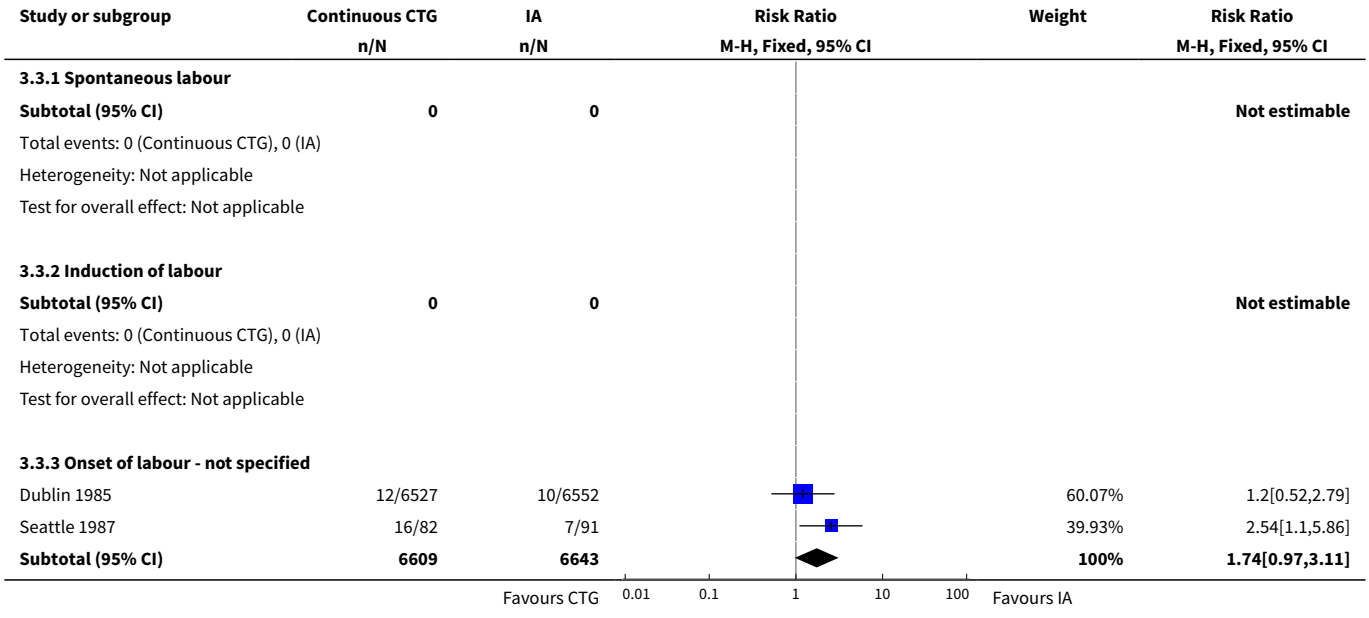
Study or subgroup	Continuous CTG n/N	IA n/N	Risk Ratio M-H, Fixed, 95% CI	Weight	Risk Ratio M-H, Fixed, 95% CI
3.1.1 Spontaneous labour					
Subtotal (95% CI)	**0**	**0**			**Not estimable**
Total events: 0 (Continuous CTG), 0 (IA)					
Heterogeneity: Not applicable					
Test for overall effect: Not applicable					
3.1.2 Induction of labour					
Subtotal (95% CI)	**0**	**0**			**Not estimable**
Total events: 0 (Continuous CTG), 0 (IA)					
Heterogeneity: Not applicable					
Test for overall effect: Not applicable					
3.1.3 Onset of labour - not specified					
Athens 1993	2/746	9/682		15.98%	0.2[0.04,0.94]
Copenhagen 1985	2/485	3/493		5.06%	0.68[0.11,4.04]
Dallas 1986	4/7288	5/7330		8.47%	0.8[0.22,3]
Denver 1976	2/242	1/241		1.7%	1.99[0.18,21.82]
Denver 1979	3/463	0/232		1.13%	3.52[0.18,67.77]
Dublin 1985	14/6530	14/6554		23.75%	1[0.48,2.1]
Melbourne 1976	1/175	1/175		1.7%	1[0.06,15.86]
Melbourne 1981	1/445	0/482		0.82%	3.25[0.13,79.55]
Pakistan 1989	4/100	5/100		8.5%	0.8[0.22,2.89]
Seattle 1987	17/122	18/124		30.34%	0.96[0.52,1.77]
Sheffield 1978	0/253	1/251		2.56%	0.33[0.01,8.08]
Subtotal (95% CI)	**16849**	**16664**		**100%**	**0.86[0.59,1.24]**
Total events: 50 (Continuous CTG), 57 (IA)					
Heterogeneity: Tau^2=0; Chi^2=6.17, df=10(P=0.8); I^2=0%					
Test for overall effect: Z=0.82(P=0.41)					
Total (95% CI)	**16849**	**16664**		**100%**	**0.86[0.59,1.24]**
Total events: 50 (Continuous CTG), 57 (IA)					
Heterogeneity: Tau^2=0; Chi^2=6.17, df=10(P=0.8); I^2=0%					
Test for overall effect: Z=0.82(P=0.41)					
Test for subgroup differences: Not applicable					

Analysis 3.2. Comparison 3 Continuous CTG versus IA (onset of labour - spontaneous/induced), Outcome 2 Neonatal seizures.

Study or subgroup	Continuous CTG n/N	IA n/N	Risk Ratio M-H, Fixed, 95% CI	Weight	Risk Ratio M-H, Fixed, 95% CI
3.2.1 Spontaneous labour					
Subtotal (95% CI)	**0**	**0**			**Not estimable**
Total events: 0 (Continuous CTG), 0 (IA)					
Heterogeneity: Not applicable					
Test for overall effect: Not applicable					



Analysis 3.3. Comparison 3 Continuous CTG versus IA (onset of labour - spontaneous/induced), Outcome 3 Cerebral palsy.



Study or subgroup	Continuous CTG n/N	IA n/N	Risk Ratio M-H, Fixed, 95% CI	Weight	Risk Ratio M-H, Fixed, 95% CI
Total events: 28 (Continuous CTG), 17 (IA)					
Heterogeneity: Tau²=0; Chi²=1.52, df=1(P=0.22); I²=34.17%					
Test for overall effect: Z=1.86(P=0.06)					
Total (95% CI)	**6609**	**6643**		**100%**	**1.74[0.97,3.11]**
Total events: 28 (Continuous CTG), 17 (IA)					
Heterogeneity: Tau²=0; Chi²=1.52, df=1(P=0.22); I²=34.17%					
Test for overall effect: Z=1.86(P=0.06)					
Test for subgroup differences: Not applicable					

Favours CTG 0.01 0.1 1 10 100 Favours IA

Analysis 3.4. Comparison 3 Continuous CTG versus IA (onset of labour - spontaneous/induced), Outcome 4 Caesarean section.

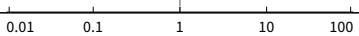
Study or subgroup	Continuous CTG n/N	IA n/N	Risk Ratio M-H, Fixed, 95% CI	Weight	Risk Ratio M-H, Fixed, 95% CI
3.4.1 Spontaneous labour					
Subtotal (95% CI)	**0**	**0**			**Not estimable**
Total events: 0 (Continuous CTG), 0 (IA)					
Heterogeneity: Not applicable					
Test for overall effect: Not applicable					
3.4.2 Induction of labour					
Subtotal (95% CI)	**0**	**0**			**Not estimable**
Total events: 0 (Continuous CTG), 0 (IA)					
Heterogeneity: Not applicable					
Test for overall effect: Not applicable					
3.4.3 Onset of labour - not specified					
Athens 1993	71/746	59/682		17.96%	1.1[0.79,1.53]
Copenhagen 1985	28/482	18/487		5.22%	1.57[0.88,2.8]
Denver 1976	40/242	16/241		4.67%	2.49[1.43,4.32]
Denver 1979	67/459	13/231		5.04%	2.59[1.46,4.6]
Dublin 1985	158/6474	144/6490		41.91%	1.1[0.88,1.37]
Melbourne 1976	39/175	24/175		6.99%	1.63[1.02,2.58]
Melbourne 1981	18/445	10/482		2.8%	1.95[0.91,4.18]
New Delhi 2006	17/50	11/50		3.21%	1.55[0.81,2.96]
Pakistan 1989	35/100	12/100		3.5%	2.92[1.61,5.28]
Seattle 1987	19/122	19/124		5.49%	1.02[0.57,1.82]
Sheffield 1978	24/253	11/251		3.22%	2.16[1.08,4.32]
Subtotal (95% CI)	**9548**	**9313**		**100%**	**1.43[1.25,1.64]**
Total events: 516 (Continuous CTG), 337 (IA)					
Heterogeneity: Tau²=0; Chi²=25.09, df=10(P=0.01); I²=60.15%					
Test for overall effect: Z=5.3(P<0.0001)					
Total (95% CI)	**9548**	**9313**		**100%**	**1.43[1.25,1.64]**
Total events: 516 (Continuous CTG), 337 (IA)					
Heterogeneity: Tau²=0; Chi²=25.09, df=10(P=0.01); I²=60.15%					
Test for overall effect: Z=5.3(P<0.0001)					

Favours CTG 0.01 0.1 1 10 100 Favours IA

Study or subgroup	Continuous CTG n/N	IA n/N	Risk Ratio M-H, Fixed, 95% CI	Weight	Risk Ratio M-H, Fixed, 95% CI
Test for subgroup differences: Not applicable					

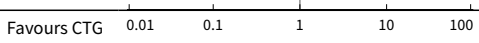
Analysis 3.5. Comparison 3 Continuous CTG versus IA (onset of labour - spontaneous/induced), Outcome 5 Instrumental vaginal birth.

Study or subgroup	Continuous CTG n/N	IA n/N	Risk Ratio M-H, Fixed, 95% CI	Weight	Risk Ratio M-H, Fixed, 95% CI
3.5.1 Spontaneous labour					
Subtotal (95% CI)	**0**	**0**			**Not estimable**
Total events: 0 (Continuous CTG), 0 (IA)					
Heterogeneity: Not applicable					
Test for overall effect: Not applicable					
3.5.2 Induction of labour					
Subtotal (95% CI)	**0**	**0**			**Not estimable**
Total events: 0 (Continuous CTG), 0 (IA)					
Heterogeneity: Not applicable					
Test for overall effect: Not applicable					
3.5.3 Onset of labour - not specified					
Athens 1993	104/746	62/682		6.77%	1.53[1.14,2.06]
Copenhagen 1985	85/482	64/487		6.65%	1.34[1,1.81]
Denver 1976	60/242	78/241		8.17%	0.77[0.58,1.02]
Denver 1979	118/459	54/231		7.51%	1.1[0.83,1.46]
Dublin 1985	528/6474	407/6490		42.47%	1.3[1.15,1.47]
Melbourne 1976	70/175	67/175		7%	1.04[0.8,1.36]
Melbourne 1981	120/445	101/482		10.13%	1.29[1.02,1.62]
New Delhi 2006	1/50	3/50		0.31%	0.33[0.04,3.1]
Pakistan 1989	38/100	27/100		2.82%	1.41[0.94,2.12]
Sheffield 1978	71/253	78/251		8.18%	0.9[0.69,1.18]
Subtotal (95% CI)	**9426**	**9189**		**100%**	**1.21[1.12,1.31]**
Total events: 1195 (Continuous CTG), 941 (IA)					
Heterogeneity: Tau^2=0; Chi^2=22.28, df=9(P=0.01); I^2=59.61%					
Test for overall effect: Z=4.75(P<0.0001)					
Total (95% CI)	**9426**	**9189**		**100%**	**1.21[1.12,1.31]**
Total events: 1195 (Continuous CTG), 941 (IA)					
Heterogeneity: Tau^2=0; Chi^2=22.28, df=9(P=0.01); I^2=59.61%					
Test for overall effect: Z=4.75(P<0.0001)					
Test for subgroup differences: Not applicable					



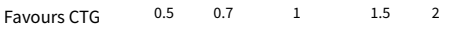
Analysis 3.6. Comparison 3 Continuous CTG versus IA (onset of labour - spontaneous/induced), Outcome 6 Cord blood acidosis.

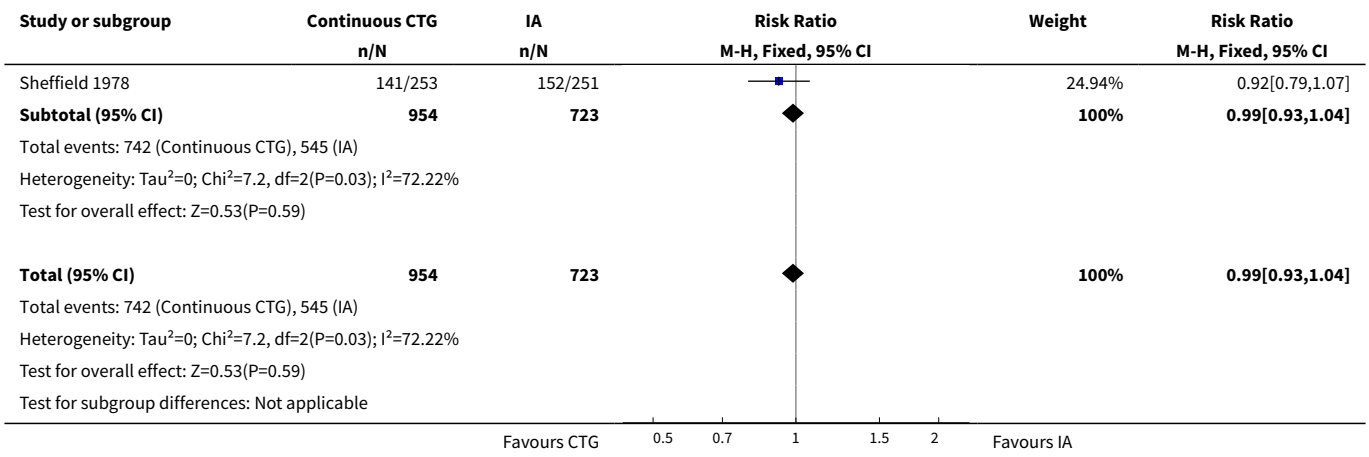
Study or subgroup	Continuous CTG n/N	IA n/N	Risk Ratio M-H, Fixed, 95% CI	Weight	Risk Ratio M-H, Fixed, 95% CI
3.6.1 Spontaneous labour					
Subtotal (95% CI)	**0**	**0**			**Not estimable**
Total events: 0 (Continuous CTG), 0 (IA)					
Heterogeneity: Not applicable					
Test for overall effect: Not applicable					
3.6.2 Induction of labour					
Subtotal (95% CI)	**0**	**0**			**Not estimable**
Total events: 0 (Continuous CTG), 0 (IA)					
Heterogeneity: Not applicable					
Test for overall effect: Not applicable					
3.6.3 Onset of labour - not specified					
Athens 1993	31/739	18/680		62.92%	1.58[0.89,2.81]
Dublin 1985	5/540	11/535		37.08%	0.45[0.16,1.29]
Subtotal (95% CI)	**1279**	**1215**		**100%**	**1.16[0.72,1.89]**
Total events: 36 (Continuous CTG), 29 (IA)					
Heterogeneity: Tau^2=0; Chi^2=4.26, df=1(P=0.04); I^2=76.53%					
Test for overall effect: Z=0.61(P=0.54)					
Total (95% CI)	**1279**	**1215**		**100%**	**1.16[0.72,1.89]**
Total events: 36 (Continuous CTG), 29 (IA)					
Heterogeneity: Tau^2=0; Chi^2=4.26, df=1(P=0.04); I^2=76.53%					
Test for overall effect: Z=0.61(P=0.54)					
Test for subgroup differences: Not applicable					



Analysis 3.7. Comparison 3 Continuous CTG versus IA (onset of labour - spontaneous/induced), Outcome 7 Any pharmacological analgesia.

Study or subgroup	Continuous CTG n/N	IA n/N	Risk Ratio M-H, Fixed, 95% CI	Weight	Risk Ratio M-H, Fixed, 95% CI
3.7.1 Spontaneous labour					
Subtotal (95% CI)	**0**	**0**			**Not estimable**
Total events: 0 (Continuous CTG), 0 (IA)					
Heterogeneity: Not applicable					
Test for overall effect: Not applicable					
3.7.2 Induction of labour					
Subtotal (95% CI)	**0**	**0**			**Not estimable**
Total events: 0 (Continuous CTG), 0 (IA)					
Heterogeneity: Not applicable					
Test for overall effect: Not applicable					
3.7.3 Onset of labour - not specified					
Denver 1976	183/242	194/241		31.78%	0.94[0.85,1.03]
Denver 1979	418/459	199/231		43.28%	1.06[1,1.12]



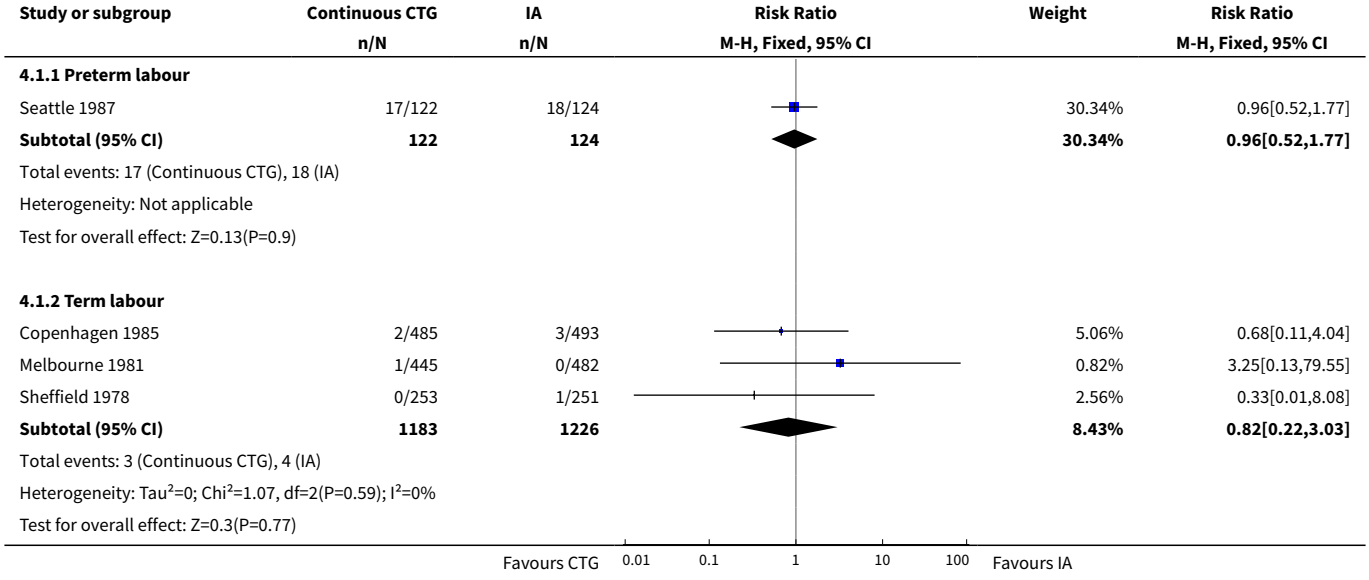


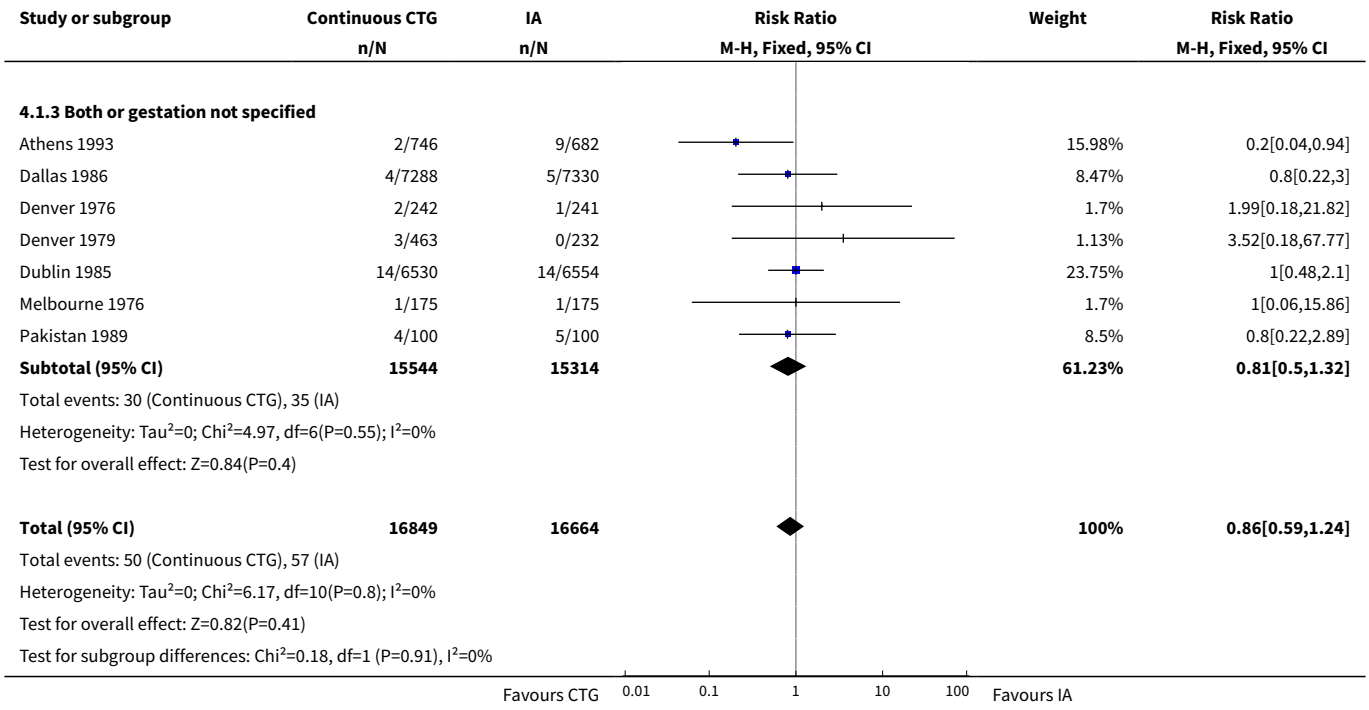
Comparison 4. Continuous CTG versus IA (preterm/term labour)

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Perinatal mortality	11	33513	Risk Ratio (M-H, Fixed, 95% CI)	0.86 [0.59, 1.24]
1.1 Preterm labour	1	246	Risk Ratio (M-H, Fixed, 95% CI)	0.96 [0.52, 1.77]
1.2 Term labour	3	2409	Risk Ratio (M-H, Fixed, 95% CI)	0.82 [0.22, 3.03]
1.3 Both or gestation not specified	7	30858	Risk Ratio (M-H, Fixed, 95% CI)	0.81 [0.50, 1.32]
2 Neonatal seizures	9	32386	Risk Ratio (M-H, Fixed, 95% CI)	0.50 [0.31, 0.80]
2.1 Preterm labour	1	246	Risk Ratio (M-H, Fixed, 95% CI)	1.02 [0.37, 2.81]
2.2 Term labour	2	1482	Risk Ratio (M-H, Fixed, 95% CI)	0.33 [0.01, 8.08]
2.3 Both or gestation not specified	6	30658	Risk Ratio (M-H, Fixed, 95% CI)	0.42 [0.24, 0.72]
3 Cerebral palsy	2	13252	Risk Ratio (M-H, Fixed, 95% CI)	1.74 [0.97, 3.11]
3.1 Preterm labour	1	173	Risk Ratio (M-H, Fixed, 95% CI)	2.54 [1.10, 5.86]
3.2 Term labour	0	0	Risk Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]
3.3 Both or gestation not specified	1	13079	Risk Ratio (M-H, Fixed, 95% CI)	1.20 [0.52, 2.79]
4 Caesarean section	11	18861	Risk Ratio (M-H, Fixed, 95% CI)	1.43 [1.25, 1.64]
4.1 Preterm labour	1	246	Risk Ratio (M-H, Fixed, 95% CI)	1.02 [0.57, 1.82]
4.2 Term labour	3	2400	Risk Ratio (M-H, Fixed, 95% CI)	1.84 [1.25, 2.69]

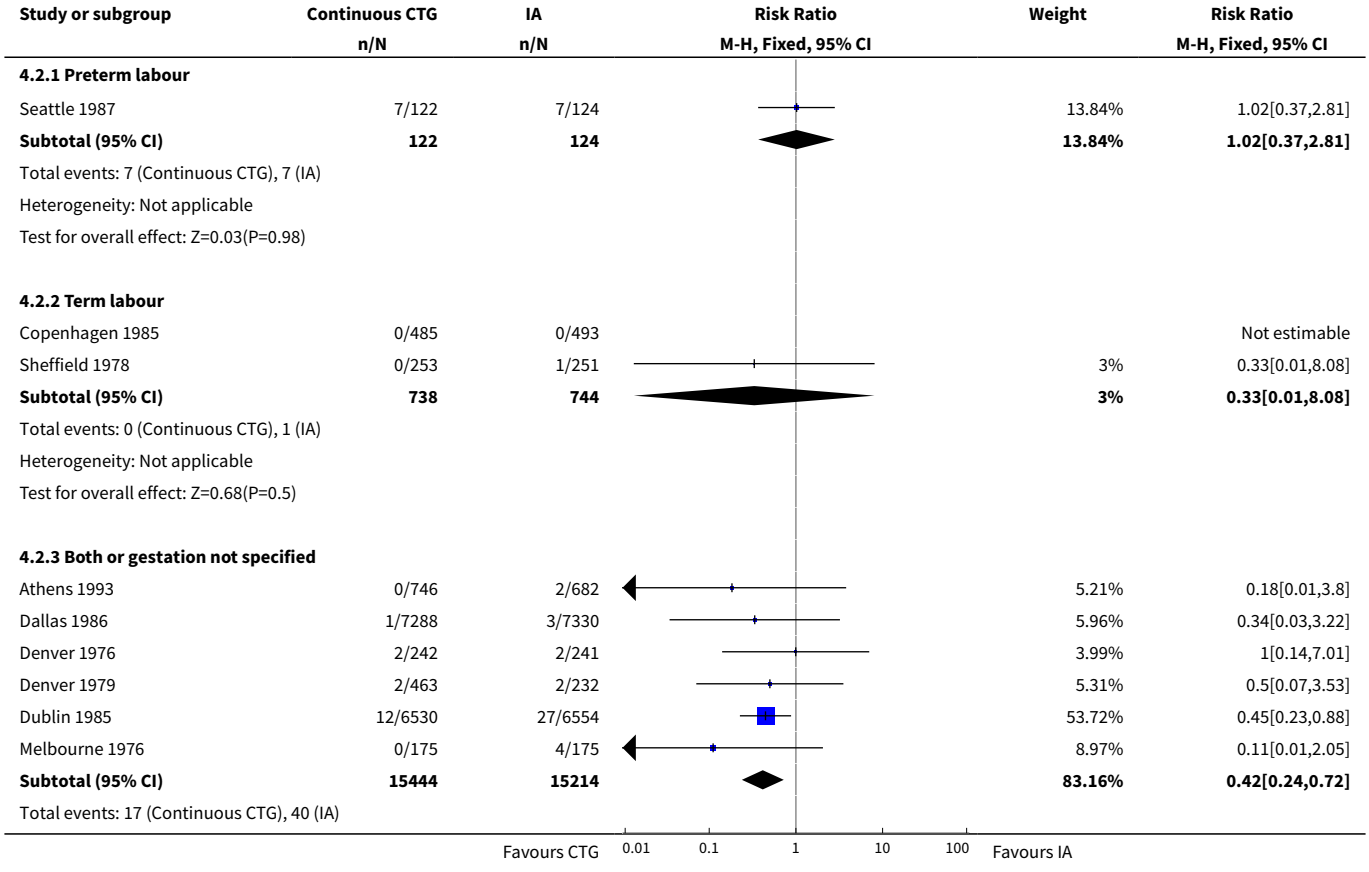
Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
4.3 Both or gestation not specified	7	16215	Risk Ratio (M-H, Fixed, 95% CI)	1.41 [1.21, 1.63]
5 Instrumental vaginal birth	10	18615	Risk Ratio (M-H, Fixed, 95% CI)	1.21 [1.12, 1.31]
5.1 Preterm labour	0	0	Risk Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]
5.2 Term labour	3	2400	Risk Ratio (M-H, Fixed, 95% CI)	1.18 [1.01, 1.37]
5.3 Both or gestation not specified	7	16215	Risk Ratio (M-H, Fixed, 95% CI)	1.22 [1.11, 1.34]
6 Cord blood acidosis	2	2494	Risk Ratio (M-H, Fixed, 95% CI)	1.16 [0.72, 1.89]
6.1 Preterm labour	0	0	Risk Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]
6.2 Term labour	0	0	Risk Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]
6.3 Both or gestation not specified	2	2494	Risk Ratio (M-H, Fixed, 95% CI)	1.16 [0.72, 1.89]
7 Any pharmacological analgesia	3	1677	Risk Ratio (M-H, Fixed, 95% CI)	0.99 [0.93, 1.04]
7.1 Preterm labour	0	0	Risk Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]
7.2 Term labour	1	504	Risk Ratio (M-H, Fixed, 95% CI)	0.92 [0.79, 1.07]
7.3 Both or gestation not specified	2	1173	Risk Ratio (M-H, Fixed, 95% CI)	1.01 [0.96, 1.06]

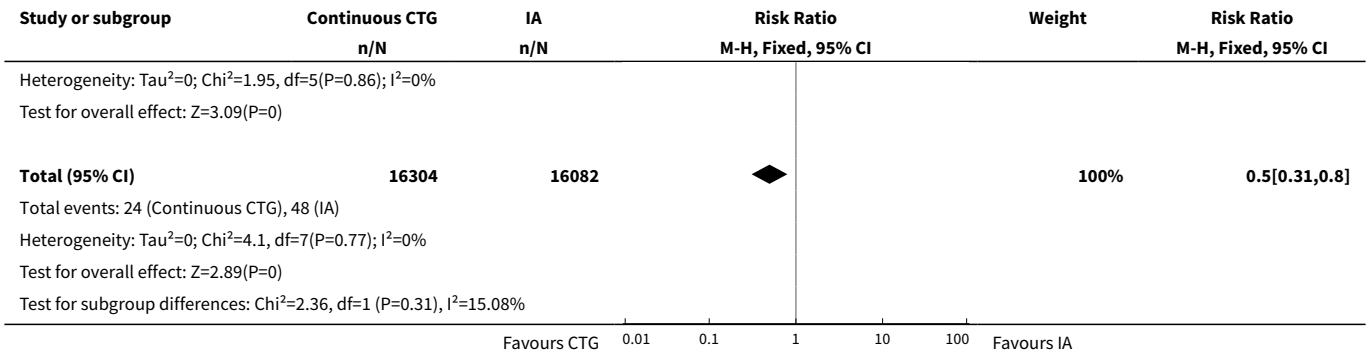
Analysis 4.1. Comparison 4 Continuous CTG versus IA (preterm/term labour), Outcome 1 Perinatal mortality.



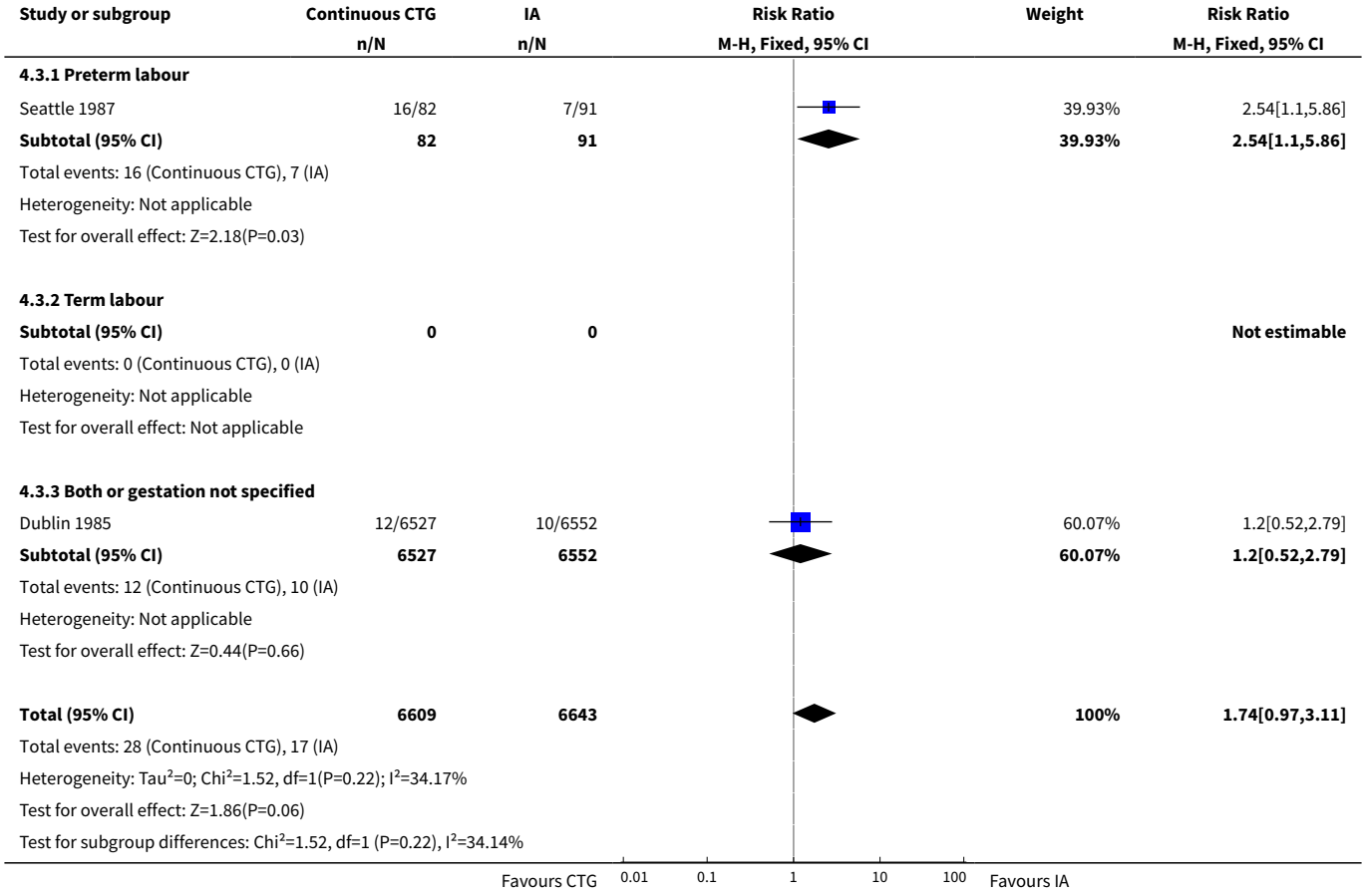


Analysis 4.2. Comparison 4 Continuous CTG versus IA (preterm/term labour), Outcome 2 Neonatal seizures.

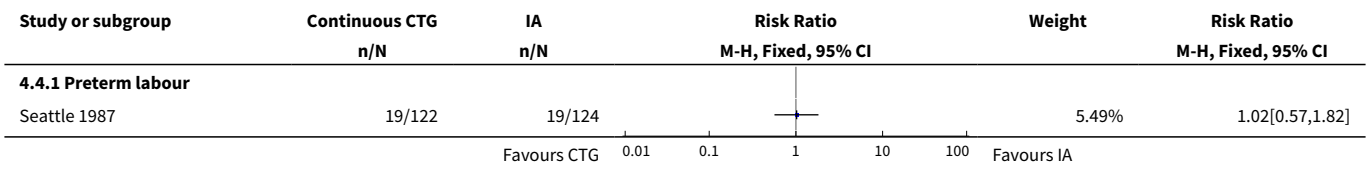


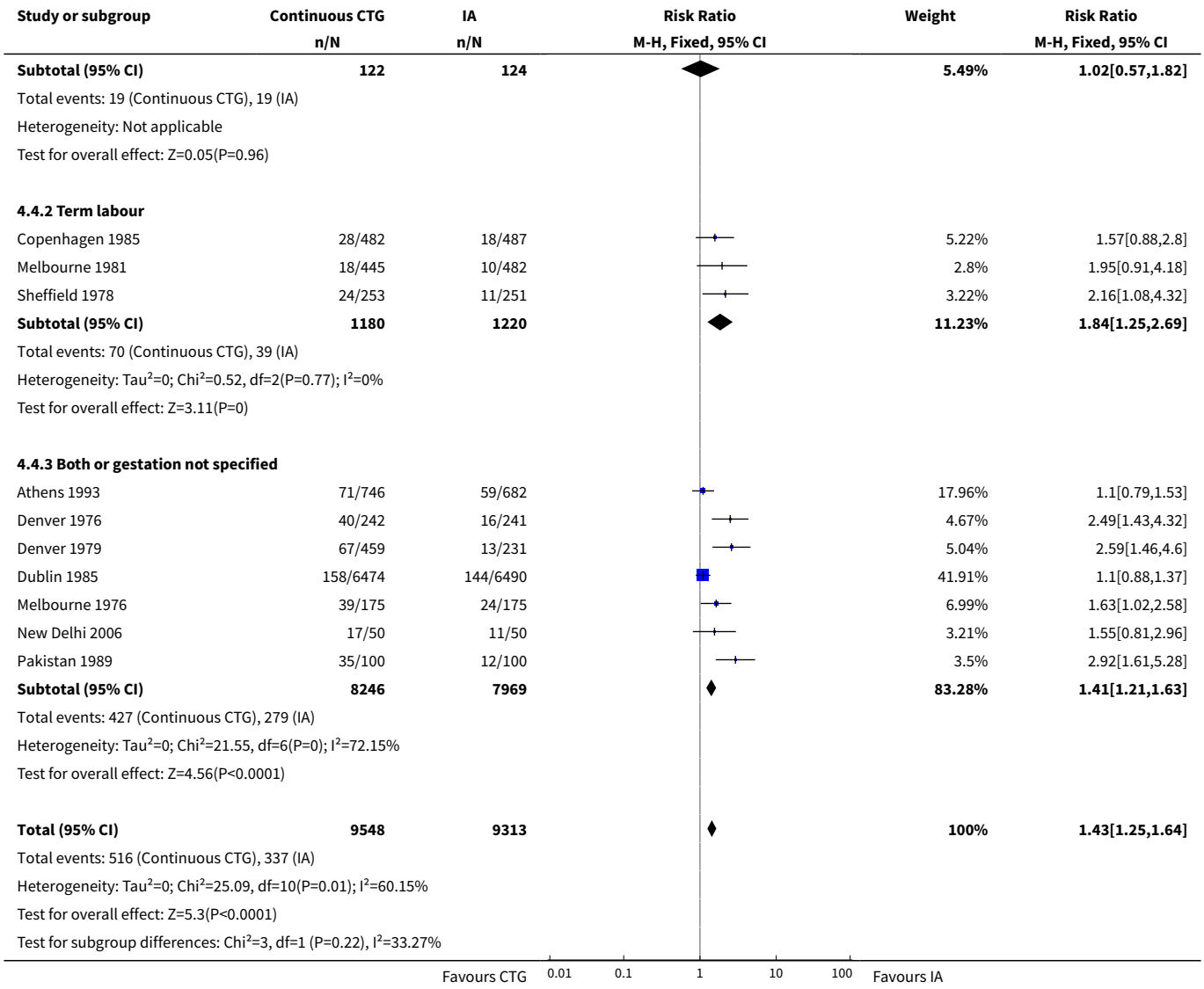


Analysis 4.3. Comparison 4 Continuous CTG versus IA (preterm/term labour), Outcome 3 Cerebral palsy.

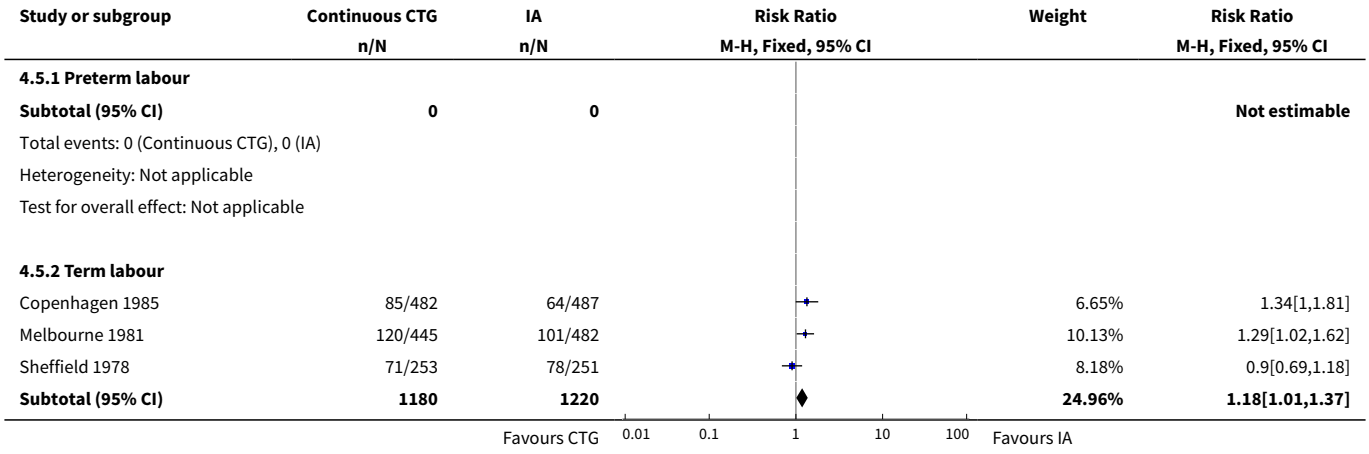


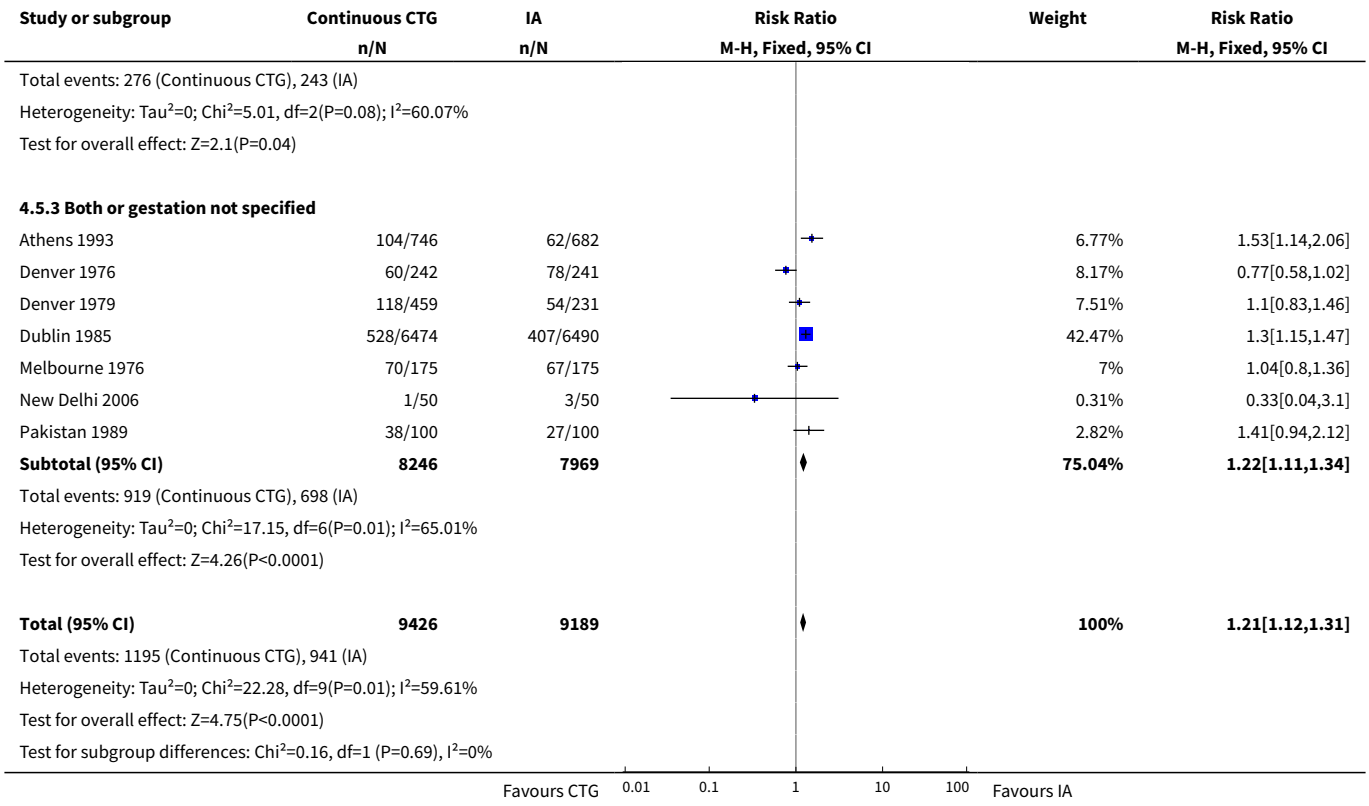
Analysis 4.4. Comparison 4 Continuous CTG versus IA (preterm/term labour), Outcome 4 Caesarean section.



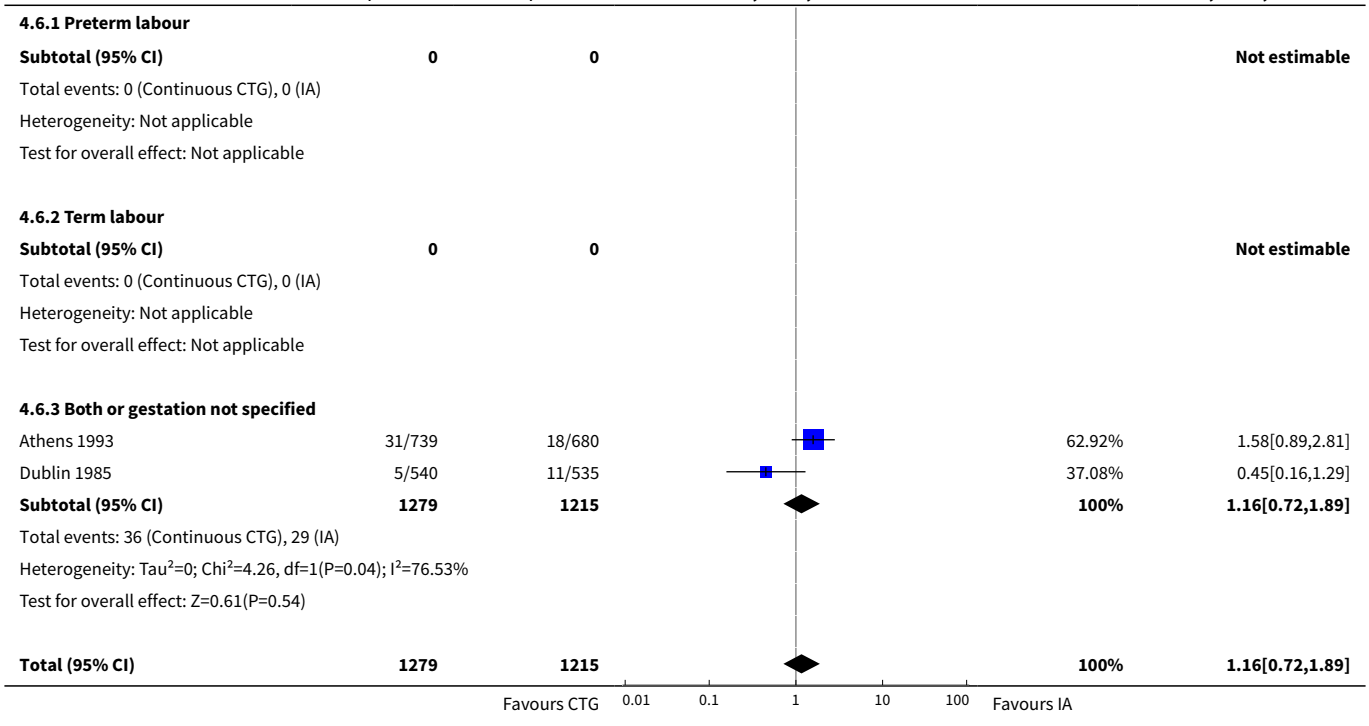


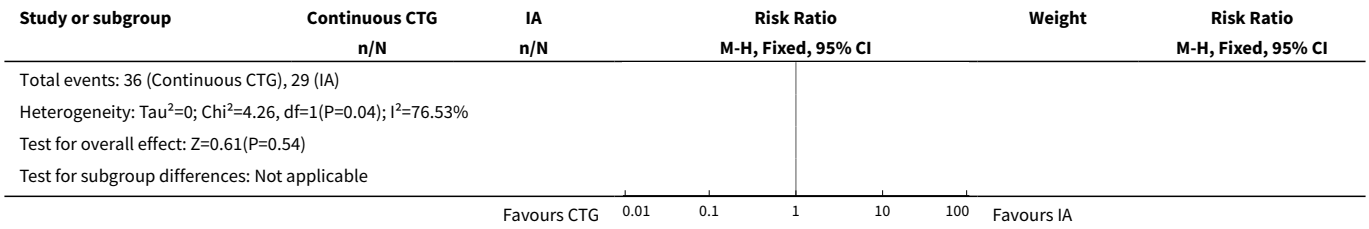
Analysis 4.5. Comparison 4 Continuous CTG versus IA (preterm/term labour), Outcome 5 Instrumental vaginal birth.



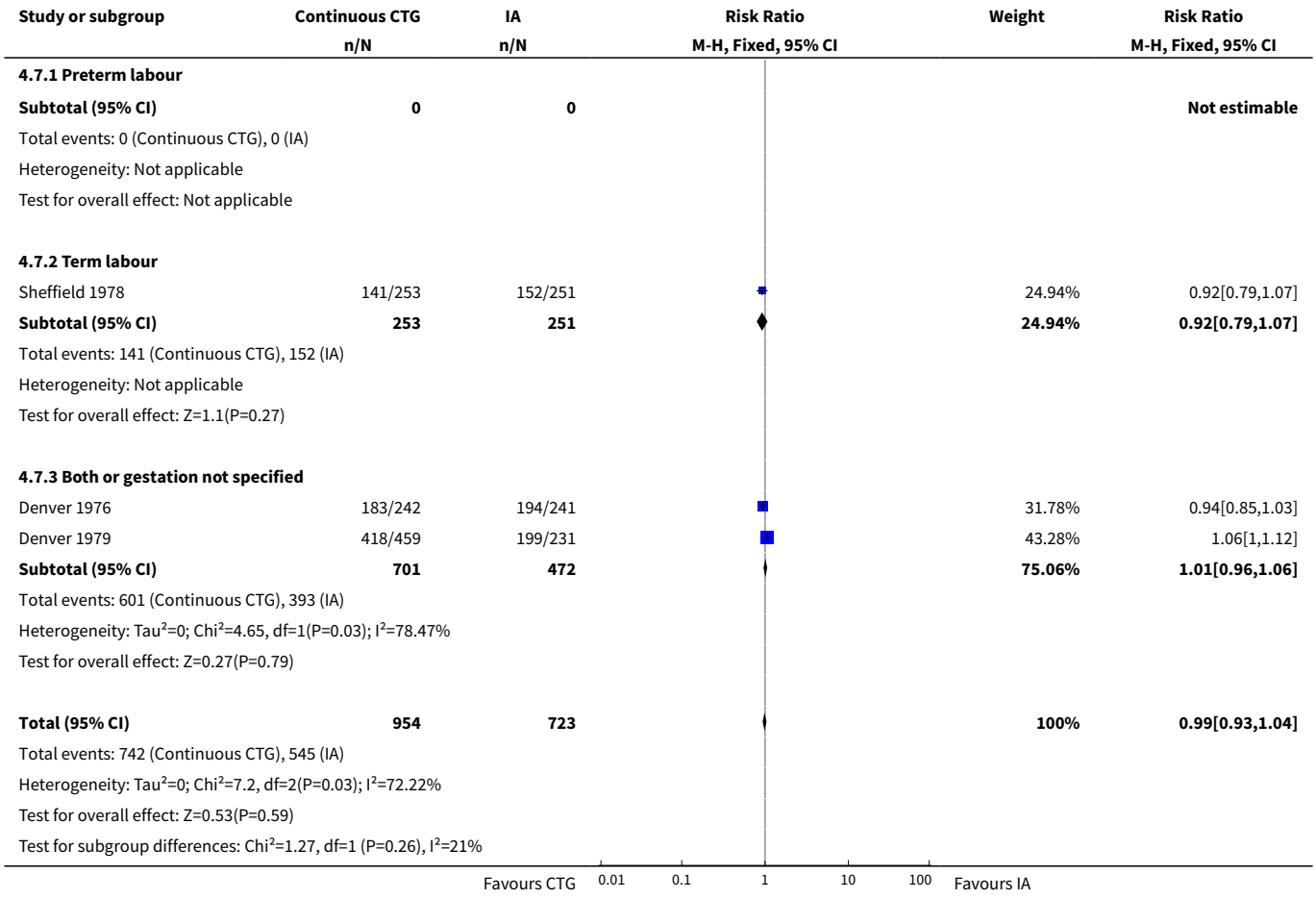


Analysis 4.6. Comparison 4 Continuous CTG versus IA (preterm/term labour), Outcome 6 Cord blood acidosis.





Analysis 4.7. Comparison 4 Continuous CTG versus IA (preterm/term labour), Outcome 7 Any pharmacological analgesia.



Comparison 5. Continuous CTG versus IA (singleton/twin pregnancy)

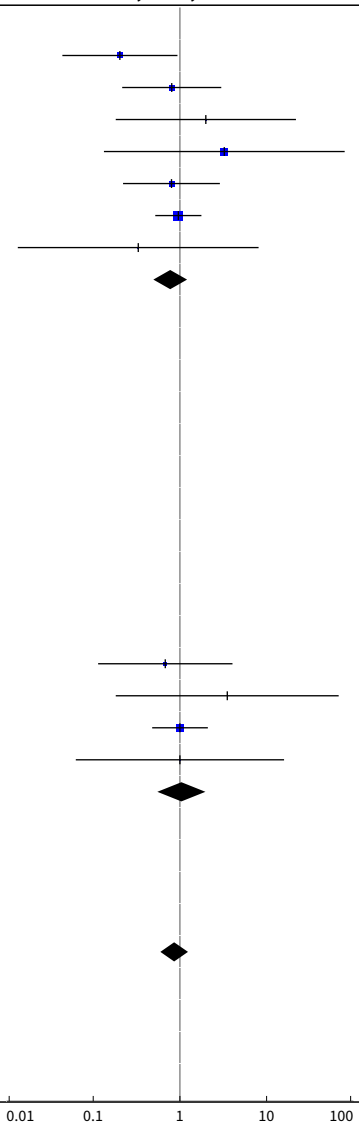
Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Perinatal mortality	11	33513	Risk Ratio (M-H, Fixed, 95% CI)	0.86 [0.59, 1.24]
1.1 Singleton	7	18406	Risk Ratio (M-H, Fixed, 95% CI)	0.77 [0.49, 1.21]

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1.2 Twins	0	0	Risk Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]
1.3 Both or singleton/twins not specified	4	15107	Risk Ratio (M-H, Fixed, 95% CI)	1.04 [0.55, 1.97]
2 Neonatal seizures	9	32386	Risk Ratio (M-H, Fixed, 95% CI)	0.50 [0.31, 0.80]
2.1 Singleton	5	17279	Risk Ratio (M-H, Fixed, 95% CI)	0.69 [0.32, 1.46]
2.2 Twins	0	0	Risk Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]
2.3 Both or singleton/twins not specified	4	15107	Risk Ratio (M-H, Fixed, 95% CI)	0.41 [0.22, 0.76]
3 Cerebral palsy	2	13252	Risk Ratio (M-H, Fixed, 95% CI)	1.74 [0.97, 3.11]
3.1 Singleton	1	173	Risk Ratio (M-H, Fixed, 95% CI)	2.54 [1.10, 5.86]
3.2 Twins	0	0	Risk Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]
3.3 Both or singleton/twins not specified	1	13079	Risk Ratio (M-H, Fixed, 95% CI)	1.20 [0.52, 2.79]
4 Caesarean section	11	18861	Risk Ratio (M-H, Fixed, 95% CI)	1.43 [1.25, 1.64]
4.1 Singleton	7	3888	Risk Ratio (M-H, Fixed, 95% CI)	1.58 [1.30, 1.93]
4.2 Twins	0	0	Risk Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]
4.3 Both or singleton/twins not specified	4	14973	Risk Ratio (M-H, Fixed, 95% CI)	1.33 [1.11, 1.59]
5 Instrumental vaginal birth	10	18615	Risk Ratio (M-H, Fixed, 95% CI)	1.21 [1.12, 1.31]
5.1 Singleton	6	3642	Risk Ratio (M-H, Fixed, 95% CI)	1.13 [1.00, 1.28]
5.2 Twins	0	0	Risk Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]
5.3 Both or singleton/twins not specified	4	14973	Risk Ratio (M-H, Fixed, 95% CI)	1.25 [1.13, 1.38]
6 Cord blood acidosis	2	2494	Risk Ratio (M-H, Fixed, 95% CI)	1.16 [0.72, 1.89]
6.1 Singleton	1	1419	Risk Ratio (M-H, Fixed, 95% CI)	1.58 [0.89, 2.81]
6.2 Twins	0	0	Risk Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]
6.3 Both or singleton/twins not specified	1	1075	Risk Ratio (M-H, Fixed, 95% CI)	0.45 [0.16, 1.29]
7 Any pharmacological analgesia	3	1677	Risk Ratio (M-H, Fixed, 95% CI)	0.99 [0.93, 1.04]

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
7.1 Singleton	2	987	Risk Ratio (M-H, Fixed, 95% CI)	0.93 [0.86, 1.01]
7.2 Twins	0	0	Risk Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]
7.3 Both or singleton/twins not specified	1	690	Risk Ratio (M-H, Fixed, 95% CI)	1.06 [1.00, 1.12]

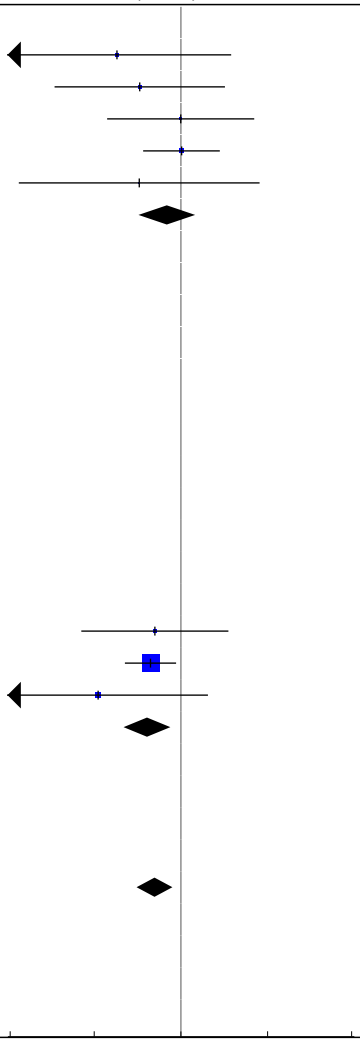
Analysis 5.1. Comparison 5 Continuous CTG versus IA (singleton/twin pregnancy), Outcome 1 Perinatal mortality.

Study or subgroup	Continuous CTG n/N	IA n/N	Risk Ratio M-H, Fixed, 95% CI	Weight	Risk Ratio M-H, Fixed, 95% CI
5.1.1 Singleton					
Athens 1993	2/746	9/682		15.98%	0.2[0.04,0.94]
Dallas 1986	4/7288	5/7330		8.47%	0.8[0.22,3]
Denver 1976	2/242	1/241		1.7%	1.99[0.18,21.82]
Melbourne 1981	1/445	0/482		0.82%	3.25[0.13,79.55]
Pakistan 1989	4/100	5/100		8.5%	0.8[0.22,2.89]
Seattle 1987	17/122	18/124		30.34%	0.96[0.52,1.77]
Sheffield 1978	0/253	1/251		2.56%	0.33[0.01,8.08]
Subtotal (95% CI)	**9196**	**9210**		**68.37%**	**0.77[0.49,1.21]**
Total events: 30 (Continuous CTG), 39 (IA)					
Heterogeneity: Tau^2=0; Chi^2=5.06, df=6(P=0.54); I^2=0%					
Test for overall effect: Z=1.12(P=0.26)					
5.1.2 Twins					
Subtotal (95% CI)	**0**	**0**			**Not estimable**
Total events: 0 (Continuous CTG), 0 (IA)					
Heterogeneity: Not applicable					
Test for overall effect: Not applicable					
5.1.3 Both or singleton/twins not specified					
Copenhagen 1985	2/485	3/493		5.06%	0.68[0.11,4.04]
Denver 1979	3/463	0/232		1.13%	3.52[0.18,67.77]
Dublin 1985	14/6530	14/6554		23.75%	1[0.48,2.1]
Melbourne 1976	1/175	1/175		1.7%	1[0.06,15.86]
Subtotal (95% CI)	**7653**	**7454**		**31.63%**	**1.04[0.55,1.97]**
Total events: 20 (Continuous CTG), 18 (IA)					
Heterogeneity: Tau^2=0; Chi^2=0.88, df=3(P=0.83); I^2=0%					
Test for overall effect: Z=0.12(P=0.9)					
Total (95% CI)	**16849**	**16664**		**100%**	**0.86[0.59,1.24]**
Total events: 50 (Continuous CTG), 57 (IA)					
Heterogeneity: Tau^2=0; Chi^2=6.17, df=10(P=0.8); I^2=0%					
Test for overall effect: Z=0.82(P=0.41)					
Test for subgroup differences: Chi^2=0.56, df=1 (P=0.46), I^2=0%					



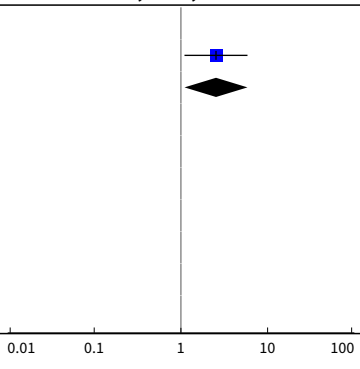
Analysis 5.2. Comparison 5 Continuous CTG versus IA (singleton/twin pregnancy), Outcome 2 Neonatal seizures.

Study or subgroup	Continuous CTG n/N	IA n/N	Risk Ratio M-H, Fixed, 95% CI	Weight	Risk Ratio M-H, Fixed, 95% CI
5.2.1 Singleton					
Athens 1993	0/746	2/682		5.21%	0.18[0.01,3.8]
Dallas 1986	1/7288	3/7330		5.96%	0.34[0.03,3.22]
Denver 1976	2/242	2/241		3.99%	1[0.14,7.01]
Seattle 1987	7/122	7/124		13.84%	1.02[0.37,2.81]
Sheffield 1978	0/253	1/251		3%	0.33[0.01,8.08]
Subtotal (95% CI)	**8651**	**8628**		**32%**	**0.69[0.32,1.46]**
Total events: 10 (Continuous CTG), 15 (IA)					
Heterogeneity: Tau^2=0; Chi^2=2.03, df=4(P=0.73); I^2=0%					
Test for overall effect: Z=0.98(P=0.33)					
5.2.2 Twins					
Subtotal (95% CI)	**0**	**0**			**Not estimable**
Total events: 0 (Continuous CTG), 0 (IA)					
Heterogeneity: Not applicable					
Test for overall effect: Not applicable					
5.2.3 Both or singleton/twins not specified					
Copenhagen 1985	0/485	0/493			Not estimable
Denver 1979	2/463	2/232		5.31%	0.5[0.07,3.53]
Dublin 1985	12/6530	27/6554		53.72%	0.45[0.23,0.88]
Melbourne 1976	0/175	4/175		8.97%	0.11[0.01,2.05]
Subtotal (95% CI)	**7653**	**7454**		**68%**	**0.41[0.22,0.76]**
Total events: 14 (Continuous CTG), 33 (IA)					
Heterogeneity: Tau^2=0; Chi^2=0.88, df=2(P=0.64); I^2=0%					
Test for overall effect: Z=2.84(P=0)					
Total (95% CI)	**16304**	**16082**		**100%**	**0.5[0.31,0.8]**
Total events: 24 (Continuous CTG), 48 (IA)					
Heterogeneity: Tau^2=0; Chi^2=4.1, df=7(P=0.77); I^2=0%					
Test for overall effect: Z=2.89(P=0)					
Test for subgroup differences: Chi^2=1.11, df=1 (P=0.29), I^2=10.24%					

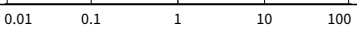


Analysis 5.3. Comparison 5 Continuous CTG versus IA (singleton/twin pregnancy), Outcome 3 Cerebral palsy.

Study or subgroup	Continuous CTG n/N	IA n/N	Risk Ratio M-H, Fixed, 95% CI	Weight	Risk Ratio M-H, Fixed, 95% CI
5.3.1 Singleton					
Seattle 1987	16/82	7/91		39.93%	2.54[1.1,5.86]
Subtotal (95% CI)	**82**	**91**		**39.93%**	**2.54[1.1,5.86]**
Total events: 16 (Continuous CTG), 7 (IA)					
Heterogeneity: Not applicable					
Test for overall effect: Z=2.18(P=0.03)					
5.3.2 Twins					
Subtotal (95% CI)	**0**	**0**			**Not estimable**
Total events: 0 (Continuous CTG), 0 (IA)					

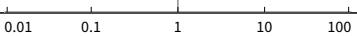


Study or subgroup	Continuous CTG n/N	IA n/N	Risk Ratio M-H, Fixed, 95% CI	Weight	Risk Ratio M-H, Fixed, 95% CI
Heterogeneity: Not applicable					
Test for overall effect: Not applicable					
5.3.3 Both or singleton/twins not specified					
Dublin 1985	12/6527	10/6552		60.07%	1.2[0.52,2.79]
Subtotal (95% CI)	**6527**	**6552**		**60.07%**	**1.2[0.52,2.79]**
Total events: 12 (Continuous CTG), 10 (IA)					
Heterogeneity: Not applicable					
Test for overall effect: Z=0.44(P=0.66)					
Total (95% CI)	**6609**	**6643**		**100%**	**1.74[0.97,3.11]**
Total events: 28 (Continuous CTG), 17 (IA)					
Heterogeneity: Tau^2=0; Chi^2=1.52, df=1(P=0.22); I^2=34.17%					
Test for overall effect: Z=1.86(P=0.06)					
Test for subgroup differences: Chi^2=1.52, df=1 (P=0.22), I^2=34.14%					



Analysis 5.4. Comparison 5 Continuous CTG versus IA (singleton/twin pregnancy), Outcome 4 Caesarean section.

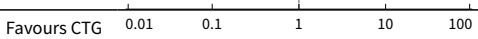
Study or subgroup	Continuous CTG n/N	IA n/N	Risk Ratio M-H, Fixed, 95% CI	Weight	Risk Ratio M-H, Fixed, 95% CI
5.4.1 Singleton					
Athens 1993	71/746	59/682		17.96%	1.1[0.79,1.53]
Denver 1976	40/242	16/241		4.67%	2.49[1.43,4.32]
Melbourne 1981	18/445	10/482		2.8%	1.95[0.91,4.18]
New Delhi 2006	17/50	11/50		3.21%	1.55[0.81,2.96]
Pakistan 1989	35/100	12/100		3.5%	2.92[1.61,5.28]
Seattle 1987	19/122	19/124		5.49%	1.02[0.57,1.82]
Sheffield 1978	24/253	11/251		3.22%	2.16[1.08,4.32]
Subtotal (95% CI)	**1958**	**1930**		**40.84%**	**1.58[1.3,1.93]**
Total events: 224 (Continuous CTG), 138 (IA)					
Heterogeneity: Tau^2=0; Chi^2=14.62, df=6(P=0.02); I^2=58.96%					
Test for overall effect: Z=4.51(P<0.0001)					
5.4.2 Twins					
Subtotal (95% CI)	**0**	**0**			**Not estimable**
Total events: 0 (Continuous CTG), 0 (IA)					
Heterogeneity: Not applicable					
Test for overall effect: Not applicable					
5.4.3 Both or singleton/twins not specified					
Copenhagen 1985	28/482	18/487		5.22%	1.57[0.88,2.8]
Denver 1979	67/459	13/231		5.04%	2.59[1.46,4.6]
Dublin 1985	158/6474	144/6490		41.91%	1.1[0.88,1.37]
Melbourne 1976	39/175	24/175		6.99%	1.63[1.02,2.58]
Subtotal (95% CI)	**7590**	**7383**		**59.16%**	**1.33[1.11,1.59]**
Total events: 292 (Continuous CTG), 199 (IA)					
Heterogeneity: Tau^2=0; Chi^2=9.05, df=3(P=0.03); I^2=66.85%					
Test for overall effect: Z=3.13(P=0)					



Study or subgroup	Continuous CTG n/N	IA n/N	Risk Ratio M-H, Fixed, 95% CI	Weight	Risk Ratio M-H, Fixed, 95% CI
Total (95% CI)	**9548**	**9313**		**100%**	**1.43[1.25,1.64]**
Total events: 516 (Continuous CTG), 337 (IA)					
Heterogeneity: Tau^2=0; Chi^2=25.09, df=10(P=0.01); I^2=60.15%					
Test for overall effect: Z=5.3(P<0.0001)					
Test for subgroup differences: Chi^2=1.58, df=1 (P=0.21), I^2=36.83%					

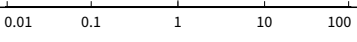
Analysis 5.5. Comparison 5 Continuous CTG versus IA (singleton/ twin pregnancy), Outcome 5 Instrumental vaginal birth.

Study or subgroup	Continuous CTG n/N	IA n/N	Risk Ratio M-H, Fixed, 95% CI	Weight	Risk Ratio M-H, Fixed, 95% CI
5.5.1 Singleton					
Athens 1993	104/746	62/682		6.77%	1.53[1.14,2.06]
Denver 1976	60/242	78/241		8.17%	0.77[0.58,1.02]
Melbourne 1981	120/445	101/482		10.13%	1.29[1.02,1.62]
New Delhi 2006	1/50	3/50		0.31%	0.33[0.04,3.1]
Pakistan 1989	38/100	27/100		2.82%	1.41[0.94,2.12]
Sheffield 1978	71/253	78/251		8.18%	0.9[0.69,1.18]
Subtotal (95% CI)	**1836**	**1806**		**36.38%**	**1.13[1,1.28]**
Total events: 394 (Continuous CTG), 349 (IA)					
Heterogeneity: Tau^2=0; Chi^2=17.32, df=5(P=0); I^2=71.14%					
Test for overall effect: Z=1.91(P=0.06)					
5.5.2 Twins					
Subtotal (95% CI)	**0**	**0**			**Not estimable**
Total events: 0 (Continuous CTG), 0 (IA)					
Heterogeneity: Not applicable					
Test for overall effect: Not applicable					
5.5.3 Both or singleton/twins not specified					
Copenhagen 1985	85/482	64/487		6.65%	1.34[1,1.81]
Denver 1979	118/459	54/231		7.51%	1.1[0.83,1.46]
Dublin 1985	528/6474	407/6490		42.47%	1.3[1.15,1.47]
Melbourne 1976	70/175	67/175		7%	1.04[0.8,1.36]
Subtotal (95% CI)	**7590**	**7383**		**63.62%**	**1.25[1.13,1.38]**
Total events: 801 (Continuous CTG), 592 (IA)					
Heterogeneity: Tau^2=0; Chi^2=3.23, df=3(P=0.36); I^2=7.21%					
Test for overall effect: Z=4.45(P<0.0001)					
Total (95% CI)	**9426**	**9189**		**100%**	**1.21[1.12,1.31]**
Total events: 1195 (Continuous CTG), 941 (IA)					
Heterogeneity: Tau^2=0; Chi^2=22.28, df=9(P=0.01); I^2=59.61%					
Test for overall effect: Z=4.75(P<0.0001)					
Test for subgroup differences: Chi^2=1.57, df=1 (P=0.21), I^2=36.34%					



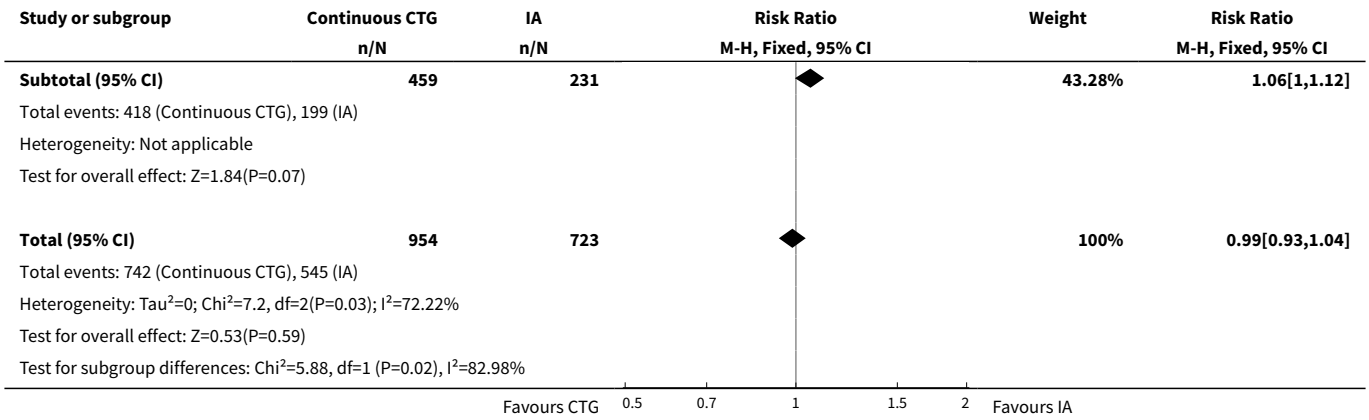
Analysis 5.6. Comparison 5 Continuous CTG versus IA (singleton/twin pregnancy), Outcome 6 Cord blood acidosis.

Study or subgroup	Continuous CTG n/N	IA n/N	Risk Ratio M-H, Fixed, 95% CI	Weight	Risk Ratio M-H, Fixed, 95% CI
5.6.1 Singleton					
Athens 1993	31/739	18/680		62.92%	1.58[0.89,2.81]
Subtotal (95% CI)	**739**	**680**		**62.92%**	**1.58[0.89,2.81]**
Total events: 31 (Continuous CTG), 18 (IA)					
Heterogeneity: Not applicable					
Test for overall effect: Z=1.58(P=0.11)					
5.6.2 Twins					
Subtotal (95% CI)	**0**	**0**			**Not estimable**
Total events: 0 (Continuous CTG), 0 (IA)					
Heterogeneity: Not applicable					
Test for overall effect: Not applicable					
5.6.3 Both or singleton/twins not specified					
Dublin 1985	5/540	11/535		37.08%	0.45[0.16,1.29]
Subtotal (95% CI)	**540**	**535**		**37.08%**	**0.45[0.16,1.29]**
Total events: 5 (Continuous CTG), 11 (IA)					
Heterogeneity: Tau^2=0; Chi^2=0, df=0(P<0.0001); I^2=100%					
Test for overall effect: Z=1.49(P=0.14)					
Total (95% CI)	**1279**	**1215**		**100%**	**1.16[0.72,1.89]**
Total events: 36 (Continuous CTG), 29 (IA)					
Heterogeneity: Tau^2=0; Chi^2=4.26, df=1(P=0.04); I^2=76.53%					
Test for overall effect: Z=0.61(P=0.54)					
Test for subgroup differences: Chi^2=4.25, df=1 (P=0.04), I^2=76.49%					



Analysis 5.7. Comparison 5 Continuous CTG versus IA (singleton/twin pregnancy), Outcome 7 Any pharmacological analgesia.

Study or subgroup	Continuous CTG n/N	IA n/N	Risk Ratio M-H, Fixed, 95% CI	Weight	Risk Ratio M-H, Fixed, 95% CI
5.7.1 Singleton					
Denver 1976	183/242	194/241		31.78%	0.94[0.85,1.03]
Sheffield 1978	141/253	152/251		24.94%	0.92[0.79,1.07]
Subtotal (95% CI)	**495**	**492**		**56.72%**	**0.93[0.86,1.01]**
Total events: 324 (Continuous CTG), 346 (IA)					
Heterogeneity: Tau^2=0; Chi^2=0.06, df=1(P=0.81); I^2=0%					
Test for overall effect: Z=1.67(P=0.1)					
5.7.2 Twins					
Subtotal (95% CI)	**0**	**0**			**Not estimable**
Total events: 0 (Continuous CTG), 0 (IA)					
Heterogeneity: Not applicable					
Test for overall effect: Not applicable					
5.7.3 Both or singleton/twins not specified					
Denver 1979	418/459	199/231		43.28%	1.06[1,1.12]



Comparison 6. Continuous CTG versus IA (access to FBS during labour - yes/no)

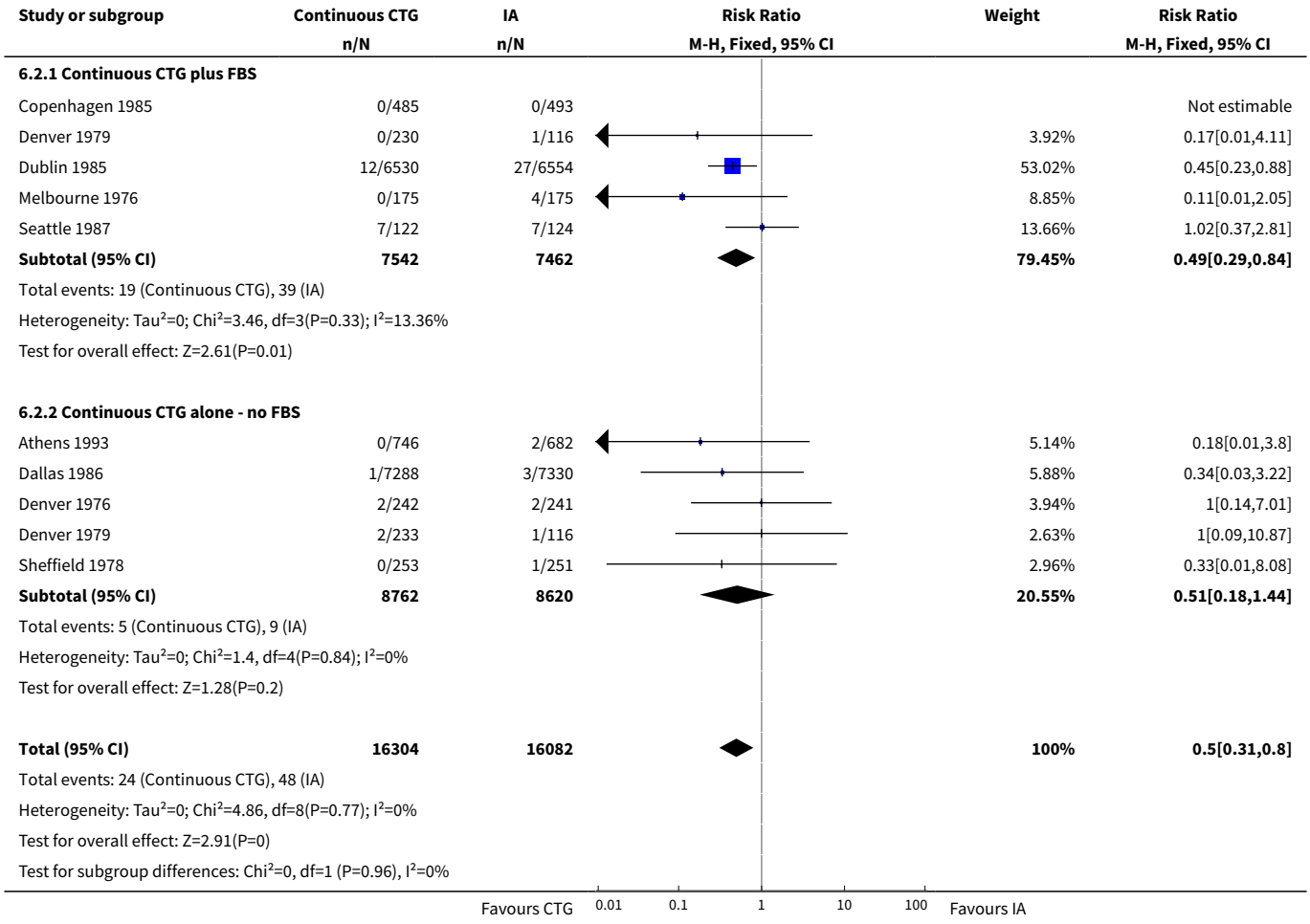
Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Perinatal mortality	11	33513	Risk Ratio (M-H, Fixed, 95% CI)	0.85 [0.59, 1.23]
1.1 Continuous CTG plus FBS	7	16131	Risk Ratio (M-H, Fixed, 95% CI)	0.97 [0.64, 1.47]
1.2 Continuous CTG alone - no FBS	5	17382	Risk Ratio (M-H, Fixed, 95% CI)	0.57 [0.26, 1.24]
2 Neonatal seizures	9	32386	Risk Ratio (M-H, Fixed, 95% CI)	0.50 [0.31, 0.80]
2.1 Continuous CTG plus FBS	5	15004	Risk Ratio (M-H, Fixed, 95% CI)	0.49 [0.29, 0.84]
2.2 Continuous CTG alone - no FBS	5	17382	Risk Ratio (M-H, Fixed, 95% CI)	0.51 [0.18, 1.44]
3 Cerebral palsy	2	13252	Risk Ratio (M-H, Fixed, 95% CI)	1.74 [0.97, 3.11]
3.1 Continuous CTG plus FBS	2	13252	Risk Ratio (M-H, Fixed, 95% CI)	1.74 [0.97, 3.11]
3.2 Continuous CTG alone - no FBS	0	0	Risk Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]
4 Caesarean section	11	18861	Risk Ratio (M-H, Fixed, 95% CI)	1.43 [1.25, 1.64]
4.1 Continuous CTG plus FBS	7	16001	Risk Ratio (M-H, Fixed, 95% CI)	1.34 [1.14, 1.58]
4.2 Continuous CTG alone - no FBS	5	2860	Risk Ratio (M-H, Fixed, 95% CI)	1.63 [1.30, 2.06]
5 Instrumental vaginal birth	10	18615	Risk Ratio (M-H, Fixed, 95% CI)	1.21 [1.12, 1.31]
5.1 Continuous CTG plus FBS	6	15755	Risk Ratio (M-H, Fixed, 95% CI)	1.27 [1.16, 1.39]
5.2 Continuous CTG alone - no FBS	5	2860	Risk Ratio (M-H, Fixed, 95% CI)	1.05 [0.90, 1.22]

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
6 Cord blood acidosis	2	2494	Risk Ratio (M-H, Fixed, 95% CI)	1.16 [0.72, 1.89]
6.1 Continuous CTG plus FBS	1	1075	Risk Ratio (M-H, Fixed, 95% CI)	0.45 [0.16, 1.29]
6.2 Continuous CTG alone - no FBS	1	1419	Risk Ratio (M-H, Fixed, 95% CI)	1.58 [0.89, 2.81]
7 Any pharmacological analgesia	3	1677	Risk Ratio (M-H, Fixed, 95% CI)	0.99 [0.93, 1.04]
7.1 Continuous CTG plus FBS	2	849	Risk Ratio (M-H, Fixed, 95% CI)	0.98 [0.90, 1.07]
7.2 Continuous CTG alone - no FBS	2	828	Risk Ratio (M-H, Fixed, 95% CI)	0.99 [0.92, 1.05]

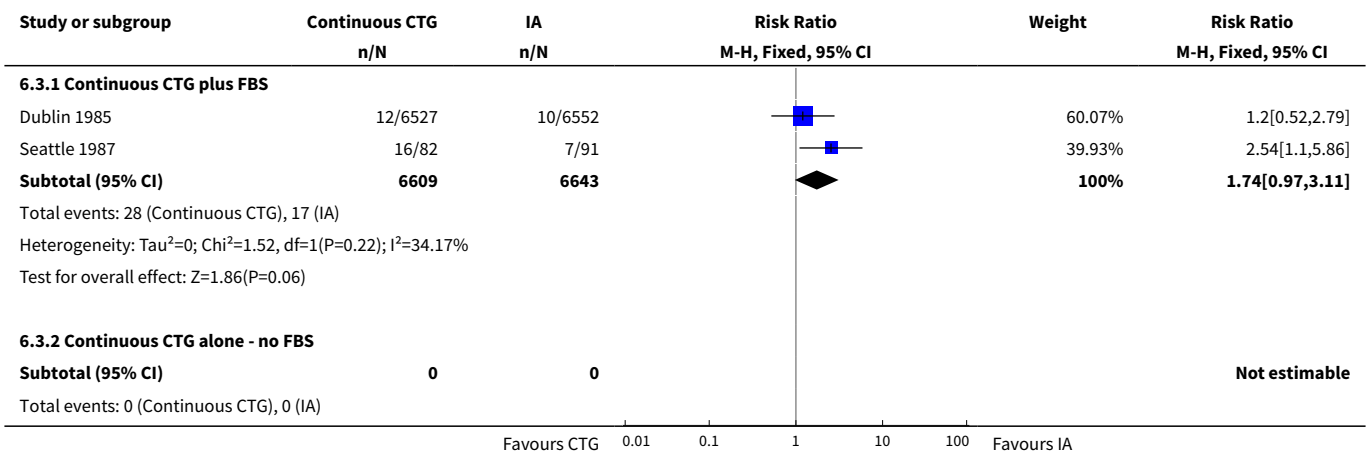
Analysis 6.1. Comparison 6 Continuous CTG versus IA (access to FBS during labour - yes/no), Outcome 1 Perinatal mortality.

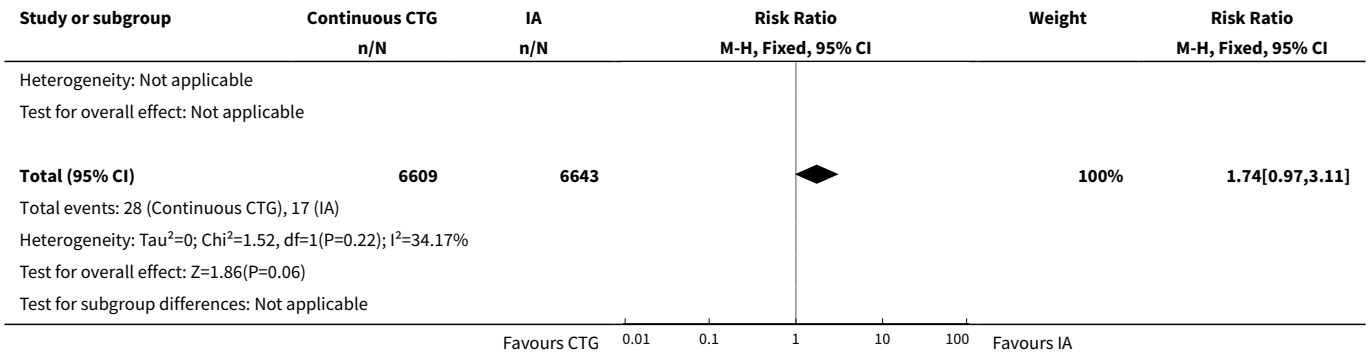
Study or subgroup	Continuous CTG n/N	IA n/N	Risk Ratio M-H, Fixed, 95% CI	Weight	Risk Ratio M-H, Fixed, 95% CI
6.1.1 Continuous CTG plus FBS					
Copenhagen 1985	2/485	3/493		5%	0.68[0.11,4.04]
Denver 1979	1/230	0/116		1.12%	1.52[0.06,37.01]
Dublin 1985	14/6530	14/6554		23.48%	1[0.48,2.1]
Melbourne 1976	1/175	1/175		1.68%	1[0.06,15.86]
Melbourne 1981	1/445	0/482		0.81%	3.25[0.13,79.55]
Pakistan 1989	4/100	5/100		8.4%	0.8[0.22,2.89]
Seattle 1987	17/122	18/124		30%	0.96[0.52,1.77]
Subtotal (95% CI)	**8087**	**8044**		**70.49%**	**0.97[0.64,1.47]**
Total events: 40 (Continuous CTG), 41 (IA)					
Heterogeneity: Tau^2=0; Chi^2=0.88, df=6(P=0.99); I^2=0%					
Test for overall effect: Z=0.14(P=0.89)					
6.1.2 Continuous CTG alone - no FBS					
Athens 1993	2/746	9/682		15.8%	0.2[0.04,0.94]
Dallas 1986	4/7288	5/7330		8.38%	0.8[0.22,3]
Denver 1976	2/242	1/241		1.68%	1.99[0.18,21.82]
Denver 1979	2/233	0/116		1.12%	2.5[0.12,51.65]
Sheffield 1978	0/253	1/251		2.53%	0.33[0.01,8.08]
Subtotal (95% CI)	**8762**	**8620**		**29.51%**	**0.57[0.26,1.24]**
Total events: 10 (Continuous CTG), 16 (IA)					
Heterogeneity: Tau^2=0; Chi^2=4.09, df=4(P=0.39); I^2=2.1%					
Test for overall effect: Z=1.41(P=0.16)					
Total (95% CI)	**16849**	**16664**		**100%**	**0.85[0.59,1.23]**
Total events: 50 (Continuous CTG), 57 (IA)					
Heterogeneity: Tau^2=0; Chi^2=5.9, df=11(P=0.88); I^2=0%					
Test for overall effect: Z=0.85(P=0.4)					
Test for subgroup differences: Chi^2=1.38, df=1 (P=0.24), I^2=27.43%					

Analysis 6.2. Comparison 6 Continuous CTG versus IA (access to FBS during labour - yes/no), Outcome 2 Neonatal seizures.

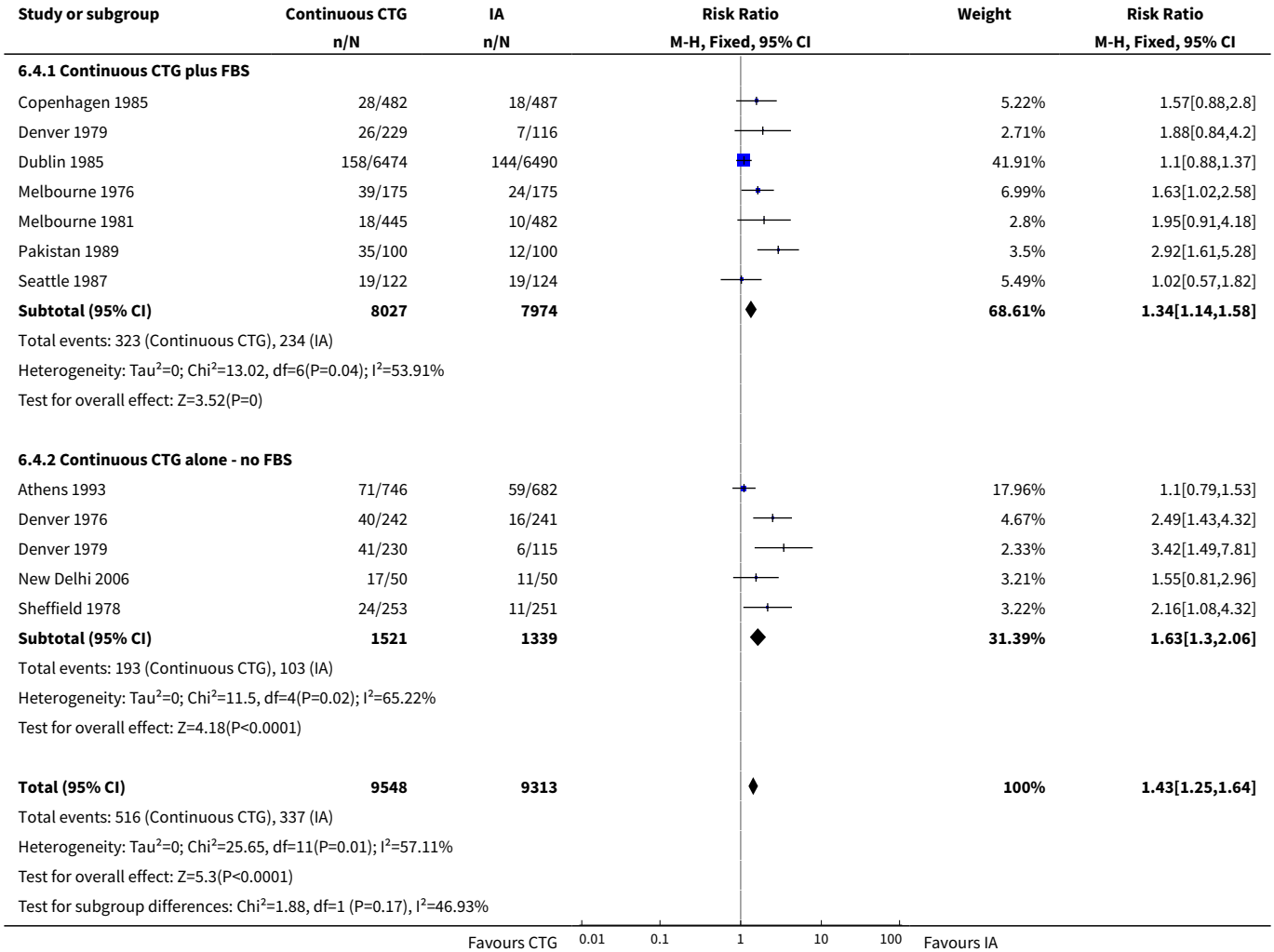


Analysis 6.3. Comparison 6 Continuous CTG versus IA (access to FBS during labour - yes/no), Outcome 3 Cerebral palsy.



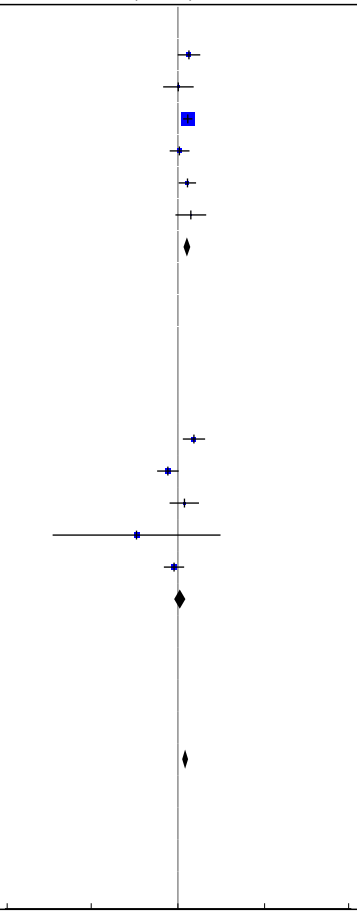


Analysis 6.4. Comparison 6 Continuous CTG versus IA (access to FBS during labour - yes/no), Outcome 4 Caesarean section.



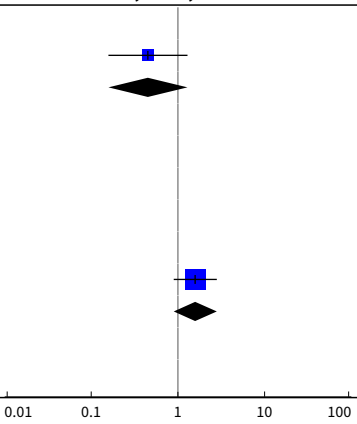
Analysis 6.5. Comparison 6 Continuous CTG versus IA (access to FBS during labour - yes/no), Outcome 5 Instrumental vaginal birth.

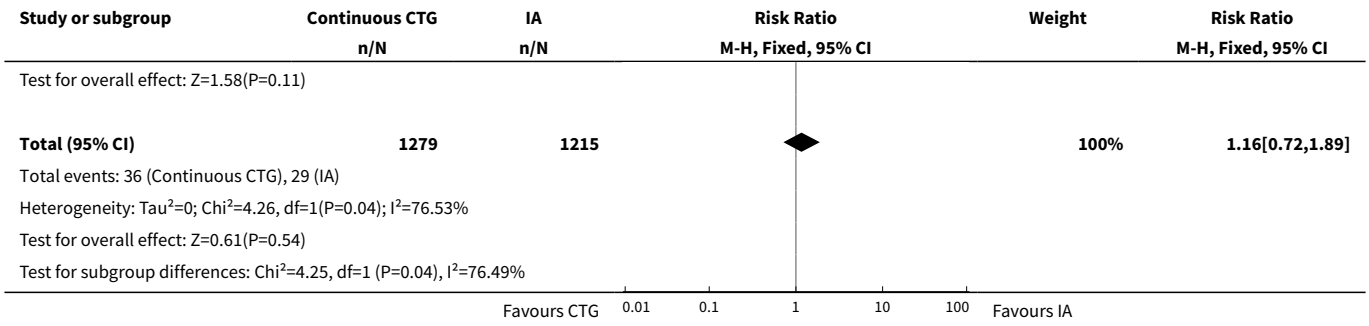
Study or subgroup	Continuous CTG n/N	IA n/N	Risk Ratio M-H, Fixed, 95% CI	Weight	Risk Ratio M-H, Fixed, 95% CI
6.5.1 Continuous CTG plus FBS					
Copenhagen 1985	85/482	64/487		6.65%	1.34[1,1.81]
Denver 1979	54/229	27/116		3.74%	1.01[0.68,1.52]
Dublin 1985	528/6474	407/6490		42.47%	1.3[1.15,1.47]
Melbourne 1976	70/175	67/175		7%	1.04[0.8,1.36]
Melbourne 1981	120/445	101/482		10.13%	1.29[1.02,1.62]
Pakistan 1989	38/100	27/100		2.82%	1.41[0.94,2.12]
Subtotal (95% CI)	**7905**	**7850**		**72.81%**	**1.27[1.16,1.39]**
Total events: 895 (Continuous CTG), 693 (IA)					
Heterogeneity: Tau^2=0; Chi^2=3.85, df=5(P=0.57); I^2=0%					
Test for overall effect: Z=5.06(P<0.0001)					
6.5.2 Continuous CTG alone - no FBS					
Athens 1993	104/746	62/682		6.77%	1.53[1.14,2.06]
Denver 1976	60/242	78/241		8.17%	0.77[0.58,1.02]
Denver 1979	64/230	27/115		3.76%	1.19[0.8,1.75]
New Delhi 2006	1/50	3/50		0.31%	0.33[0.04,3.1]
Sheffield 1978	71/253	78/251		8.18%	0.9[0.69,1.18]
Subtotal (95% CI)	**1521**	**1339**		**27.19%**	**1.05[0.9,1.22]**
Total events: 300 (Continuous CTG), 248 (IA)					
Heterogeneity: Tau^2=0; Chi^2=13.54, df=4(P=0.01); I^2=70.46%					
Test for overall effect: Z=0.65(P=0.51)					
Total (95% CI)	**9426**	**9189**		**100%**	**1.21[1.12,1.31]**
Total events: 1195 (Continuous CTG), 941 (IA)					
Heterogeneity: Tau^2=0; Chi^2=22.59, df=10(P=0.01); I^2=55.72%					
Test for overall effect: Z=4.75(P<0.0001)					
Test for subgroup differences: Chi^2=4.34, df=1 (P=0.04), I^2=76.95%					



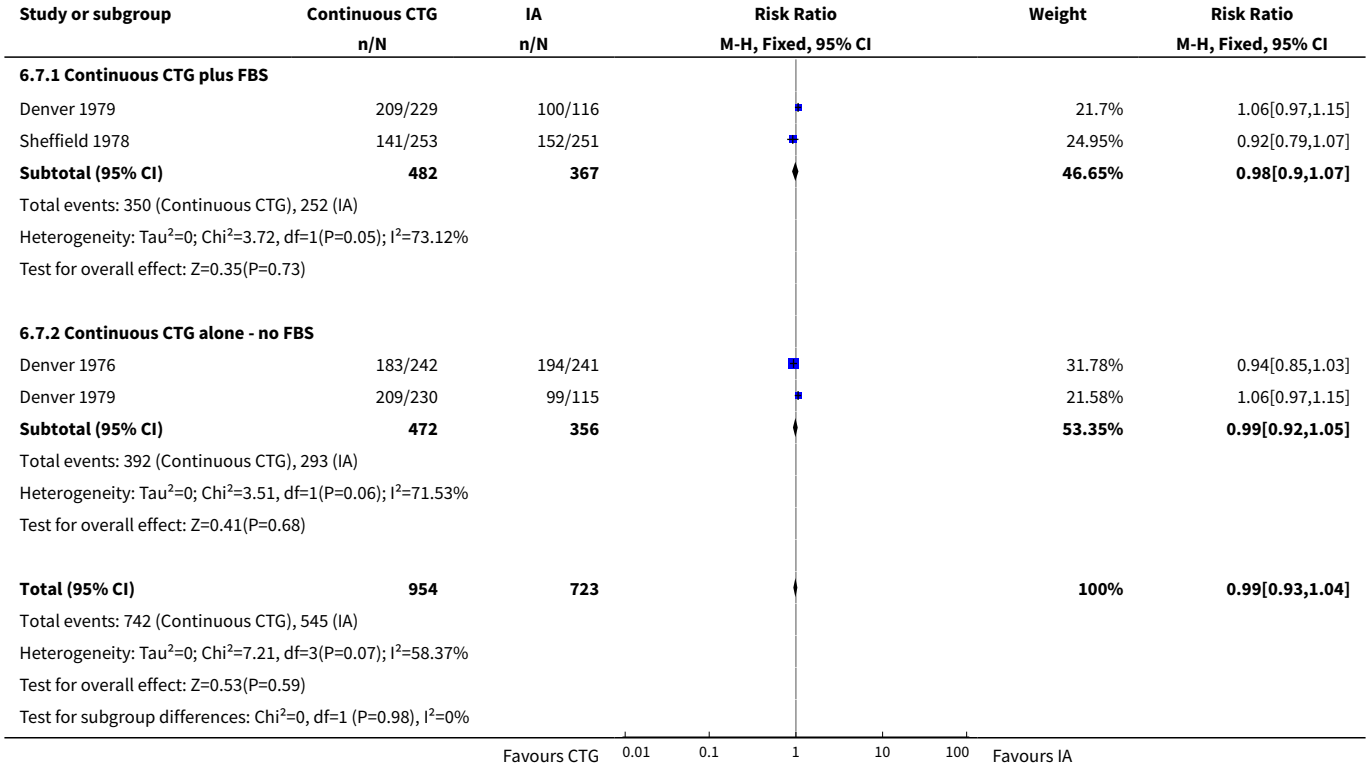
Analysis 6.6. Comparison 6 Continuous CTG versus IA (access to FBS during labour - yes/no), Outcome 6 Cord blood acidosis.

Study or subgroup	Continuous CTG n/N	IA n/N	Risk Ratio M-H, Fixed, 95% CI	Weight	Risk Ratio M-H, Fixed, 95% CI
6.6.1 Continuous CTG plus FBS					
Dublin 1985	5/540	11/535		37.08%	0.45[0.16,1.29]
Subtotal (95% CI)	**540**	**535**		**37.08%**	**0.45[0.16,1.29]**
Total events: 5 (Continuous CTG), 11 (IA)					
Heterogeneity: Tau^2=0; Chi^2=0, df=0(P<0.0001); I^2=100%					
Test for overall effect: Z=1.49(P=0.14)					
6.6.2 Continuous CTG alone - no FBS					
Athens 1993	31/739	18/680		62.92%	1.58[0.89,2.81]
Subtotal (95% CI)	**739**	**680**		**62.92%**	**1.58[0.89,2.81]**
Total events: 31 (Continuous CTG), 18 (IA)					
Heterogeneity: Not applicable					





Analysis 6.7. Comparison 6 Continuous CTG versus IA (access to FBS during labour - yes/no), Outcome 7 Any pharmacological analgesia.



Comparison 7. Continuous CTG versus IA (primiparous/multiparous women)

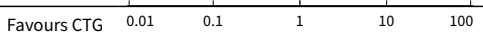
Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Perinatal mortality	11	33513	Risk Ratio (M-H, Fixed, 95% CI)	0.86 [0.59, 1.24]
1.1 Primaparous women	0	0	Risk Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]
1.2 Multiparous women	0	0	Risk Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1.3 Both or parity not specified	11	33513	Risk Ratio (M-H, Fixed, 95% CI)	0.86 [0.59, 1.24]
2 Neonatal seizures	9	32386	Risk Ratio (M-H, Fixed, 95% CI)	0.50 [0.31, 0.80]
2.1 Primaparous women	0	0	Risk Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]
2.2 Multiparous women	0	0	Risk Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]
2.3 Both or parity not specified	9	32386	Risk Ratio (M-H, Fixed, 95% CI)	0.50 [0.31, 0.80]
3 Cerebral palsy	2	13252	Risk Ratio (M-H, Fixed, 95% CI)	1.74 [0.97, 3.11]
3.1 Primaparous women	0	0	Risk Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]
3.2 Multiparous women	0	0	Risk Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]
3.3 Both or parity not specified	2	13252	Risk Ratio (M-H, Fixed, 95% CI)	1.74 [0.97, 3.11]
4 Caesarean section	11	18961	Risk Ratio (M-H, Fixed, 95% CI)	1.44 [1.26, 1.64]
4.1 Primaparous women	0	0	Risk Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]
4.2 Multiparous women	1	100	Risk Ratio (M-H, Fixed, 95% CI)	1.55 [0.81, 2.96]
4.3 Both or parity not specified	11	18861	Risk Ratio (M-H, Fixed, 95% CI)	1.43 [1.25, 1.64]
5 Instrumental vaginal birth	10	18715	Risk Ratio (M-H, Fixed, 95% CI)	1.21 [1.12, 1.30]
5.1 Primaparous women	0	0	Risk Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]
5.2 Multiparous women	1	100	Risk Ratio (M-H, Fixed, 95% CI)	0.33 [0.04, 3.10]
5.3 Both or parity not specified	10	18615	Risk Ratio (M-H, Fixed, 95% CI)	1.21 [1.12, 1.31]
6 Cord blood acidosis	2	2494	Risk Ratio (M-H, Fixed, 95% CI)	1.16 [0.72, 1.89]
6.1 Primaparous women	0	0	Risk Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]
6.2 Multiparous women	0	0	Risk Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]
6.3 Both or parity not specified	2	2494	Risk Ratio (M-H, Fixed, 95% CI)	1.16 [0.72, 1.89]
7 Any pharmacological analgesia	3	1677	Risk Ratio (M-H, Fixed, 95% CI)	0.99 [0.93, 1.04]
7.1 Primaparous women	0	0	Risk Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]
7.2 Multiparous women	0	0	Risk Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]

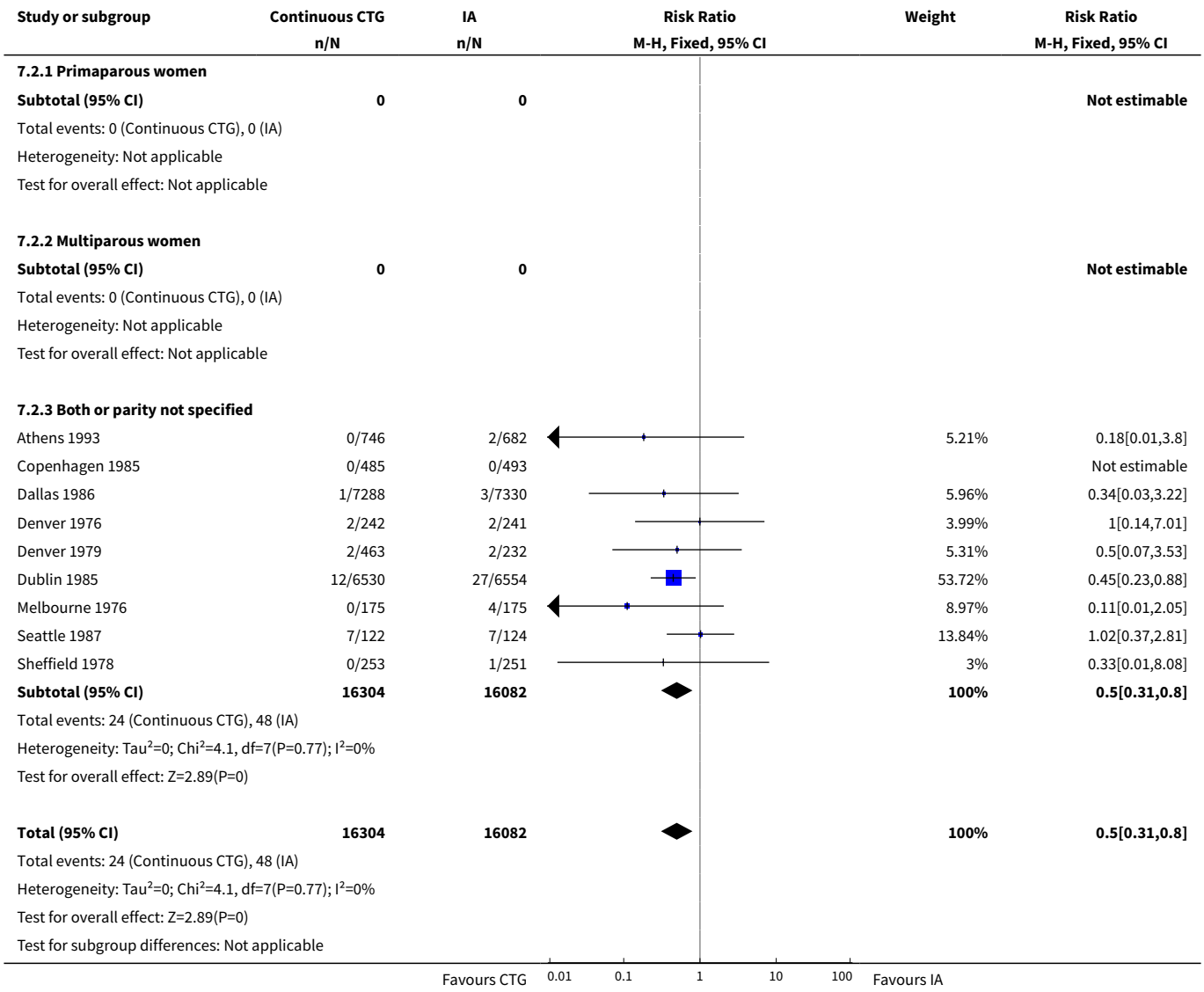
Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
7.3 Both or parity not specified	3	1677	Risk Ratio (M-H, Fixed, 95% CI)	0.99 [0.93, 1.04]

Analysis 7.1. Comparison 7 Continuous CTG versus IA (primiparous/multiparous women), Outcome 1 Perinatal mortality.

Study or subgroup	Continuous CTG n/N	IA n/N	Risk Ratio M-H, Fixed, 95% CI	Weight	Risk Ratio M-H, Fixed, 95% CI
7.1.1 Primaparous women					
Subtotal (95% CI)	**0**	**0**			**Not estimable**
Total events: 0 (Continuous CTG), 0 (IA)					
Heterogeneity: Not applicable					
Test for overall effect: Not applicable					
7.1.2 Multiparous women					
Subtotal (95% CI)	**0**	**0**			**Not estimable**
Total events: 0 (Continuous CTG), 0 (IA)					
Heterogeneity: Not applicable					
Test for overall effect: Not applicable					
7.1.3 Both or parity not specified					
Athens 1993	2/746	9/682		15.98%	0.2[0.04,0.94]
Copenhagen 1985	2/485	3/493		5.06%	0.68[0.11,4.04]
Dallas 1986	4/7288	5/7330		8.47%	0.8[0.22,3]
Denver 1976	2/242	1/241		1.7%	1.99[0.18,21.82]
Denver 1979	3/463	0/232		1.13%	3.52[0.18,67.77]
Dublin 1985	14/6530	14/6554		23.75%	1[0.48,2.1]
Melbourne 1976	1/175	1/175		1.7%	1[0.06,15.86]
Melbourne 1981	1/445	0/482		0.82%	3.25[0.13,79.55]
Pakistan 1989	4/100	5/100		8.5%	0.8[0.22,2.89]
Seattle 1987	17/122	18/124		30.34%	0.96[0.52,1.77]
Sheffield 1978	0/253	1/251		2.56%	0.33[0.01,8.08]
Subtotal (95% CI)	**16849**	**16664**		**100%**	**0.86[0.59,1.24]**
Total events: 50 (Continuous CTG), 57 (IA)					
Heterogeneity: Tau^2=0; Chi^2=6.17, df=10(P=0.8); I^2=0%					
Test for overall effect: Z=0.82(P=0.41)					
Total (95% CI)	**16849**	**16664**		**100%**	**0.86[0.59,1.24]**
Total events: 50 (Continuous CTG), 57 (IA)					
Heterogeneity: Tau^2=0; Chi^2=6.17, df=10(P=0.8); I^2=0%					
Test for overall effect: Z=0.82(P=0.41)					
Test for subgroup differences: Not applicable					

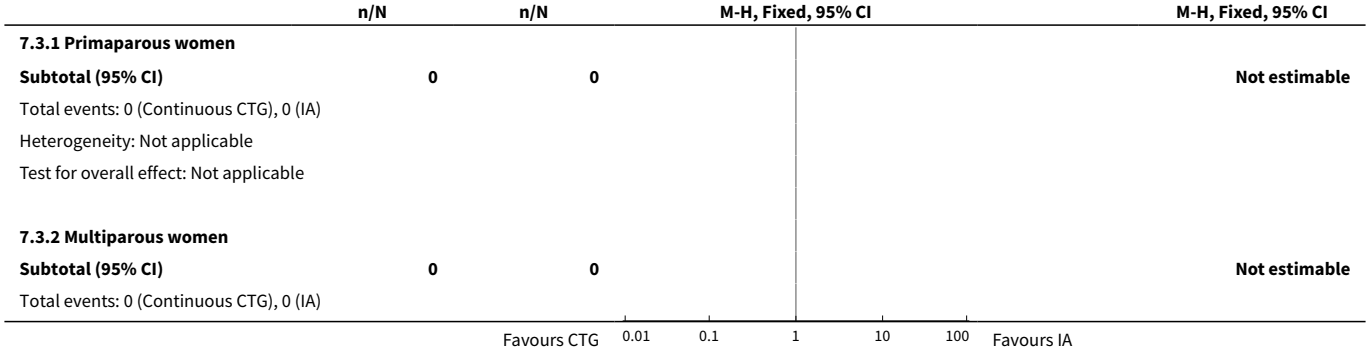


Analysis 7.2. Comparison 7 Continuous CTG versus IA (primiparous/multiparous women), Outcome 2 Neonatal seizures.

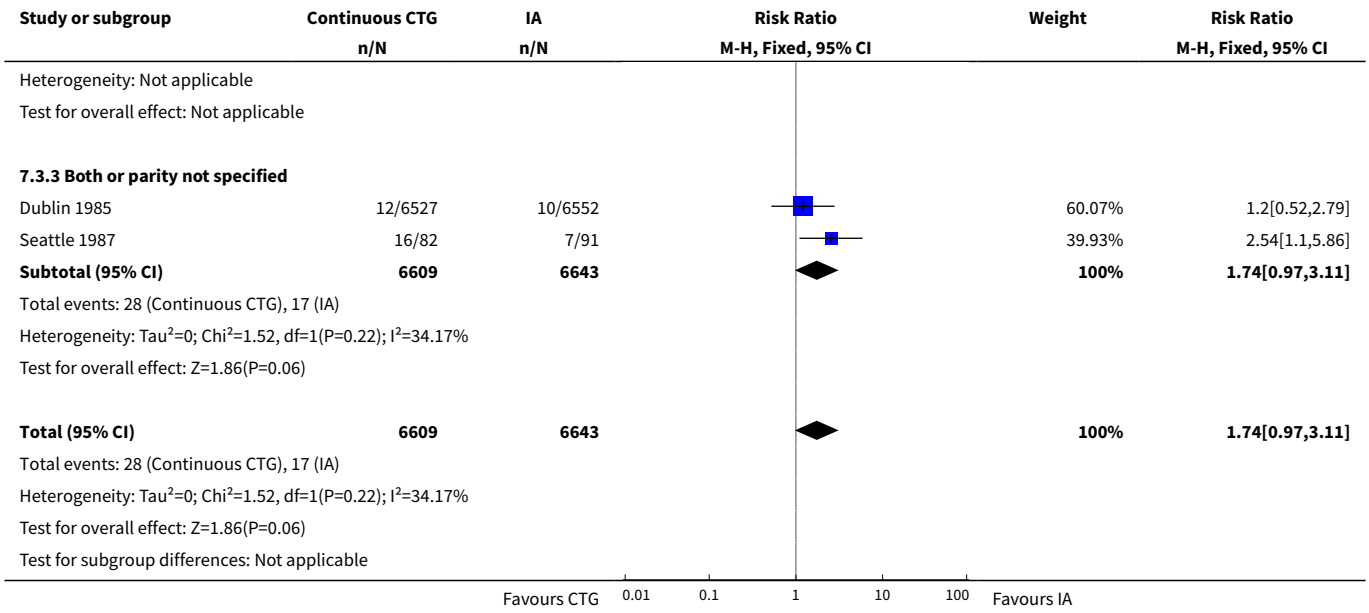


Study or subgroup	Continuous CTG n/N	IA n/N	Risk Ratio M-H, Fixed, 95% CI	Weight	Risk Ratio M-H, Fixed, 95% CI
7.2.1 Primaparous women					
Subtotal (95% CI)	**0**	**0**			**Not estimable**
Total events: 0 (Continuous CTG), 0 (IA)					
Heterogeneity: Not applicable					
Test for overall effect: Not applicable					
7.2.2 Multiparous women					
Subtotal (95% CI)	**0**	**0**			**Not estimable**
Total events: 0 (Continuous CTG), 0 (IA)					
Heterogeneity: Not applicable					
Test for overall effect: Not applicable					
7.2.3 Both or parity not specified					
Athens 1993	0/746	2/682		5.21%	0.18[0.01,3.8]
Copenhagen 1985	0/485	0/493			Not estimable
Dallas 1986	1/7288	3/7330		5.96%	0.34[0.03,3.22]
Denver 1976	2/242	2/241		3.99%	1[0.14,7.01]
Denver 1979	2/463	2/232		5.31%	0.5[0.07,3.53]
Dublin 1985	12/6530	27/6554		53.72%	0.45[0.23,0.88]
Melbourne 1976	0/175	4/175		8.97%	0.11[0.01,2.05]
Seattle 1987	7/122	7/124		13.84%	1.02[0.37,2.81]
Sheffield 1978	0/253	1/251		3%	0.33[0.01,8.08]
Subtotal (95% CI)	**16304**	**16082**		**100%**	**0.5[0.31,0.8]**
Total events: 24 (Continuous CTG), 48 (IA)					
Heterogeneity: Tau^2=0; Chi^2=4.1, df=7(P=0.77); I^2=0%					
Test for overall effect: Z=2.89(P=0)					
Total (95% CI)	**16304**	**16082**		**100%**	**0.5[0.31,0.8]**
Total events: 24 (Continuous CTG), 48 (IA)					
Heterogeneity: Tau^2=0; Chi^2=4.1, df=7(P=0.77); I^2=0%					
Test for overall effect: Z=2.89(P=0)					
Test for subgroup differences: Not applicable					

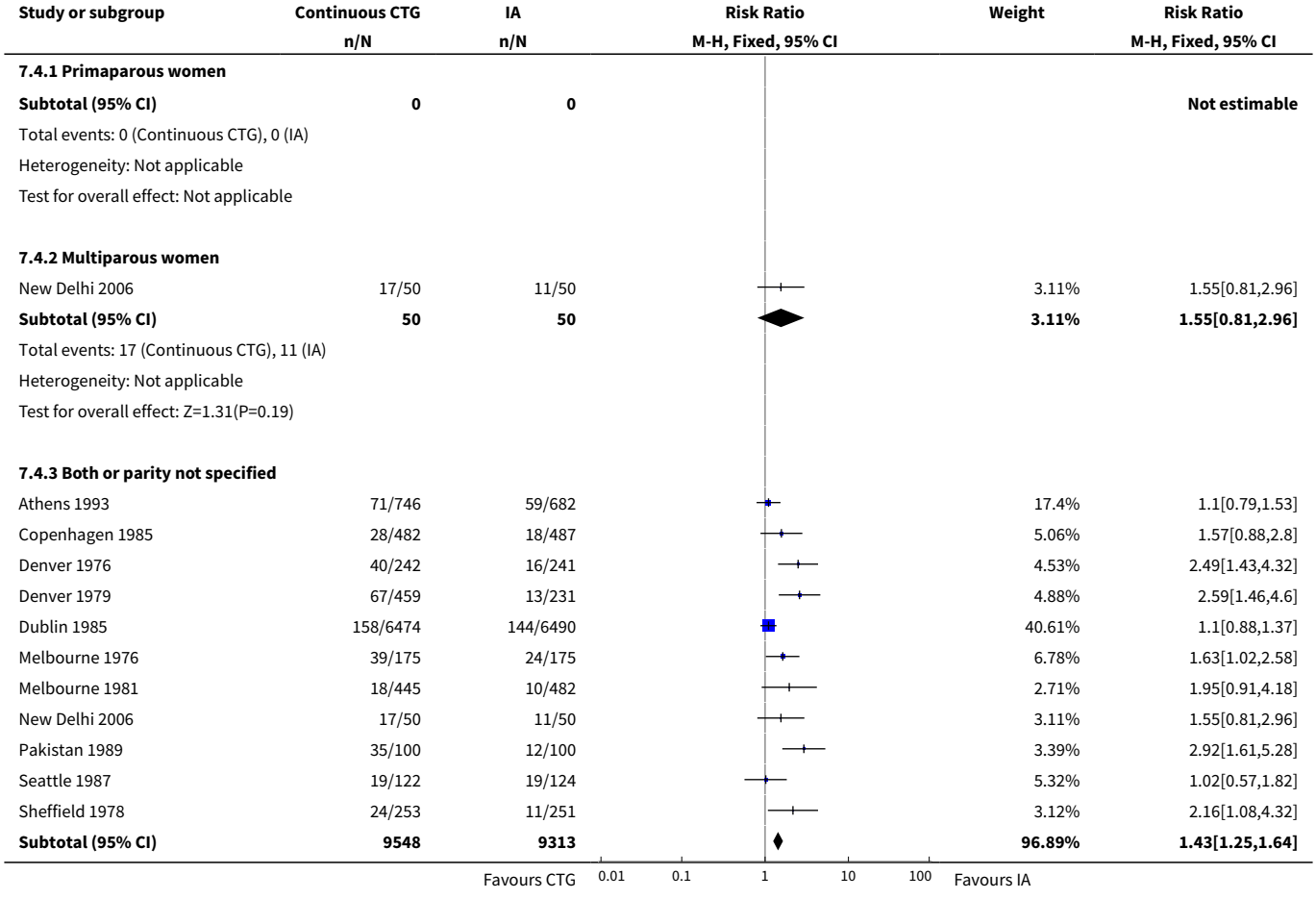
Analysis 7.3. Comparison 7 Continuous CTG versus IA (primiparous/multiparous women), Outcome 3 Cerebral palsy.

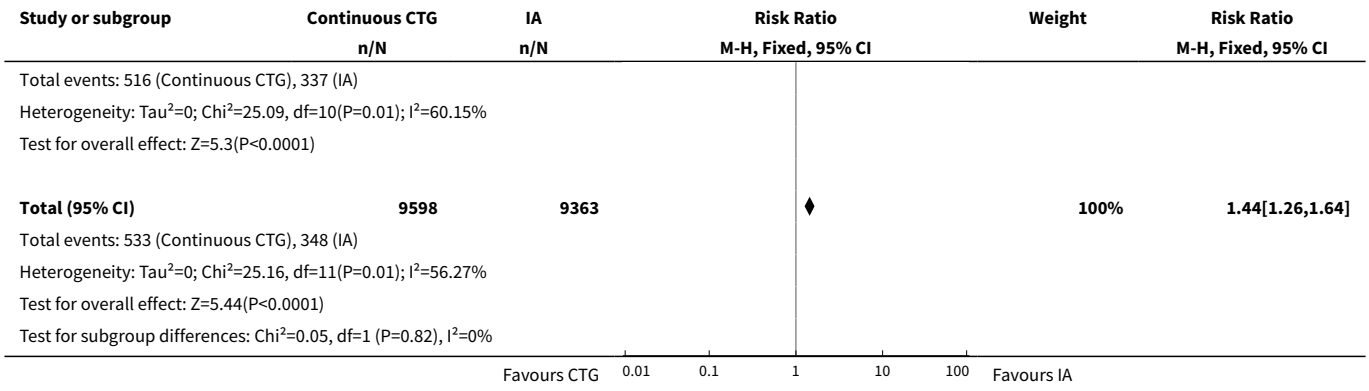


Study or subgroup	Continuous CTG n/N	IA n/N	Risk Ratio M-H, Fixed, 95% CI	Weight	Risk Ratio M-H, Fixed, 95% CI
7.3.1 Primaparous women					
Subtotal (95% CI)	**0**	**0**			**Not estimable**
Total events: 0 (Continuous CTG), 0 (IA)					
Heterogeneity: Not applicable					
Test for overall effect: Not applicable					
7.3.2 Multiparous women					
Subtotal (95% CI)	**0**	**0**			**Not estimable**
Total events: 0 (Continuous CTG), 0 (IA)					

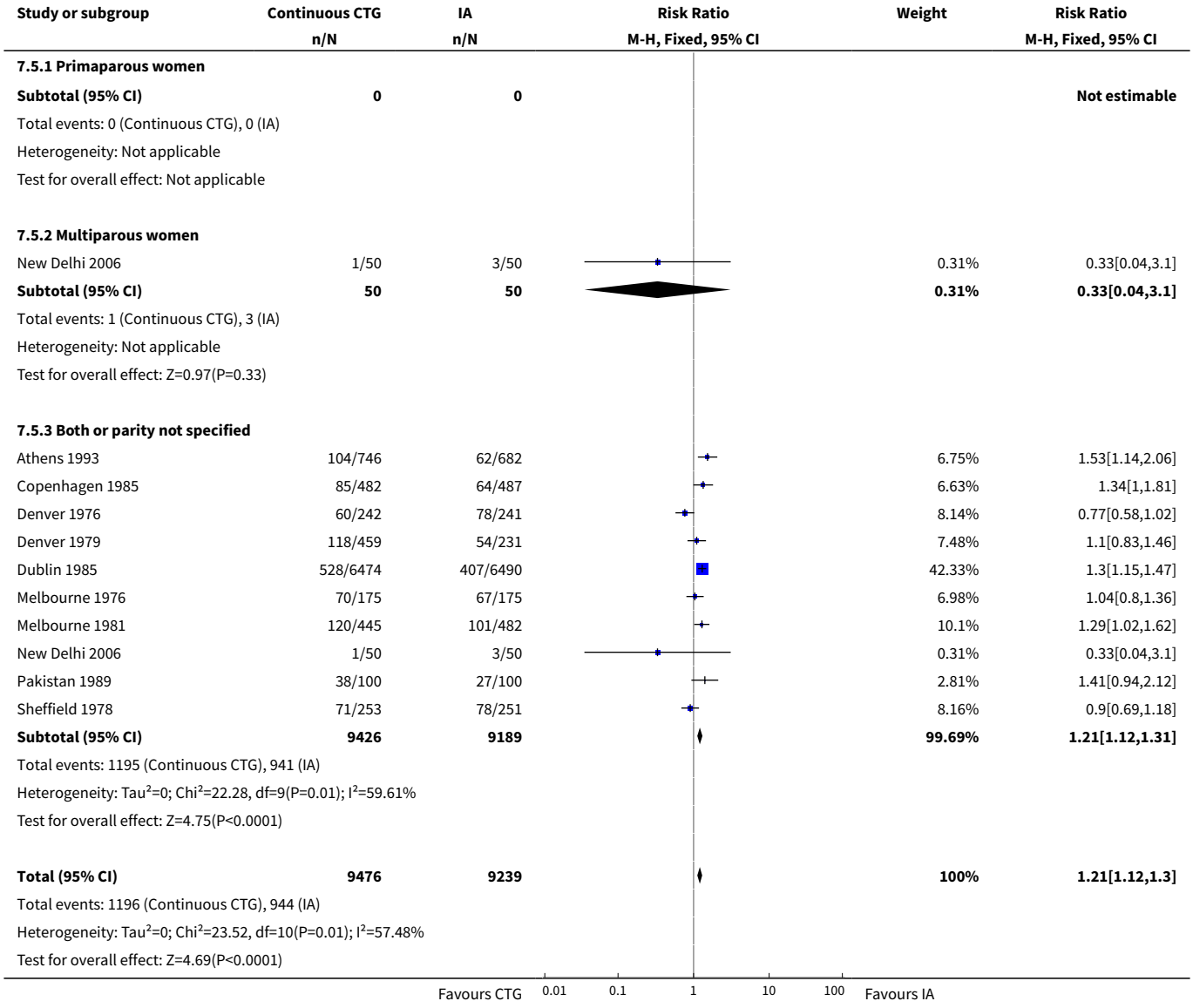


Analysis 7.4. Comparison 7 Continuous CTG versus IA (primiparous/multiparous women), Outcome 4 Caesarean section.





Analysis 7.5. Comparison 7 Continuous CTG versus IA (primiparous/ multiparous women), Outcome 5 Instrumental vaginal birth.



Study or subgroup	Continuous CTG n/N	IA n/N	Risk Ratio M-H, Fixed, 95% CI	Weight	Risk Ratio M-H, Fixed, 95% CI
Test for subgroup differences: Chi²=1.28, df=1 (P=0.26), I²=21.94%					

Favours CTG 0.01 0.1 1 10 100 Favours IA

Analysis 7.6. Comparison 7 Continuous CTG versus IA (primiparous/ multiparous women), Outcome 6 Cord blood acidosis.

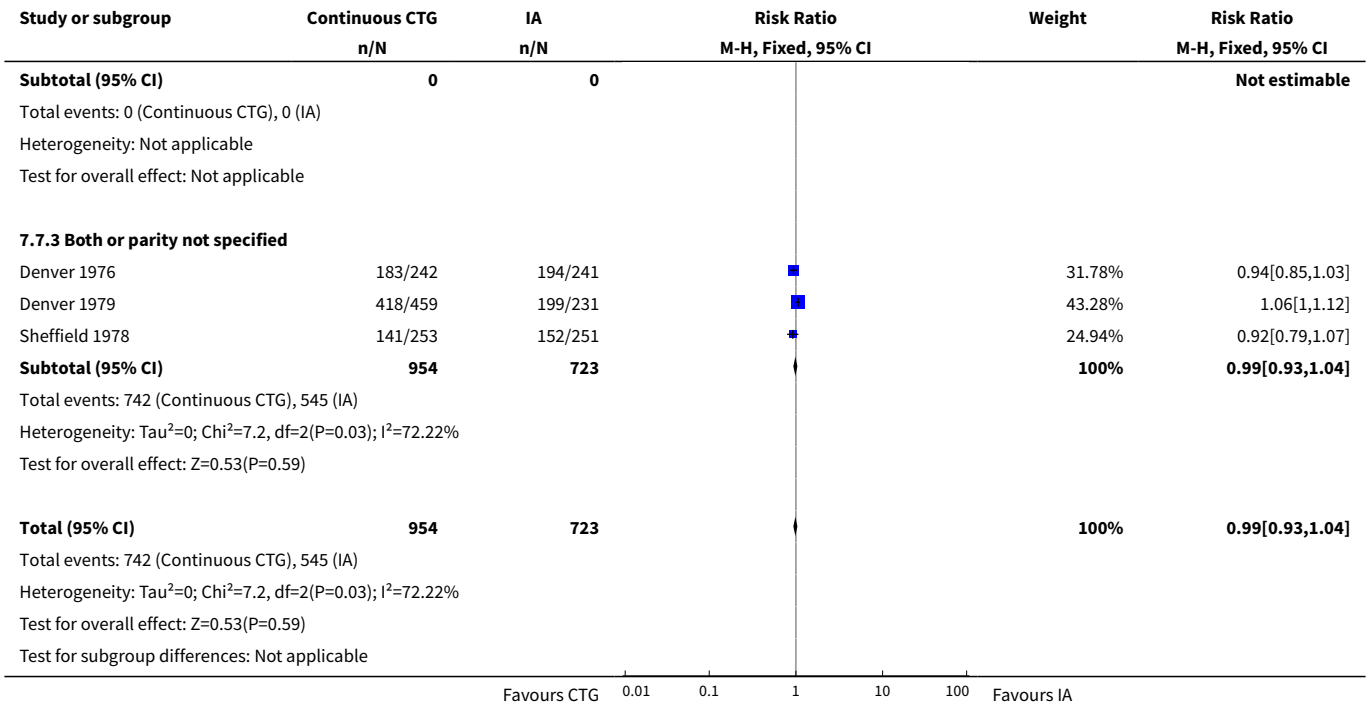
Study or subgroup	Continuous CTG n/N	IA n/N	Risk Ratio M-H, Fixed, 95% CI	Weight	Risk Ratio M-H, Fixed, 95% CI
7.6.1 Primaparous women					
Subtotal (95% CI)	**0**	**0**			**Not estimable**
Total events: 0 (Continuous CTG), 0 (IA)					
Heterogeneity: Not applicable					
Test for overall effect: Not applicable					
7.6.2 Multiparous women					
Subtotal (95% CI)	**0**	**0**			**Not estimable**
Total events: 0 (Continuous CTG), 0 (IA)					
Heterogeneity: Not applicable					
Test for overall effect: Not applicable					
7.6.3 Both or parity not specified					
Athens 1993	31/739	18/680		62.92%	1.58[0.89,2.81]
Dublin 1985	5/540	11/535		37.08%	0.45[0.16,1.29]
Subtotal (95% CI)	**1279**	**1215**		**100%**	**1.16[0.72,1.89]**
Total events: 36 (Continuous CTG), 29 (IA)					
Heterogeneity: Tau²=0; Chi²=4.26, df=1(P=0.04); I²=76.53%					
Test for overall effect: Z=0.61(P=0.54)					
Total (95% CI)	**1279**	**1215**		**100%**	**1.16[0.72,1.89]**
Total events: 36 (Continuous CTG), 29 (IA)					
Heterogeneity: Tau²=0; Chi²=4.26, df=1(P=0.04); I²=76.53%					
Test for overall effect: Z=0.61(P=0.54)					
Test for subgroup differences: Not applicable					

Favours CTG 0.01 0.1 1 10 100 Favours IA

Analysis 7.7. Comparison 7 Continuous CTG versus IA (primiparous/ multiparous women), Outcome 7 Any pharmacological analgesia.

Study or subgroup	Continuous CTG n/N	IA n/N	Risk Ratio M-H, Fixed, 95% CI	Weight	Risk Ratio M-H, Fixed, 95% CI
7.7.1 Primaparous women					
Subtotal (95% CI)	**0**	**0**			**Not estimable**
Total events: 0 (Continuous CTG), 0 (IA)					
Heterogeneity: Not applicable					
Test for overall effect: Not applicable					
7.7.2 Multiparous women					

Favours CTG 0.01 0.1 1 10 100 Favours IA



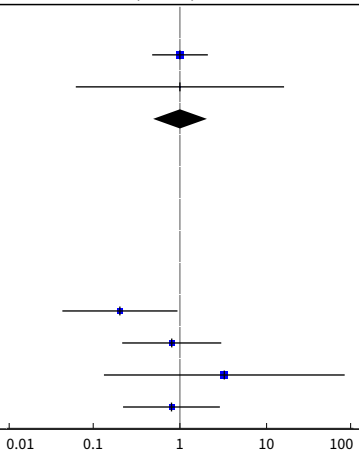
Comparison 8. Continuous CTG versus IA (sensitivity analysis: high and low quality studies)

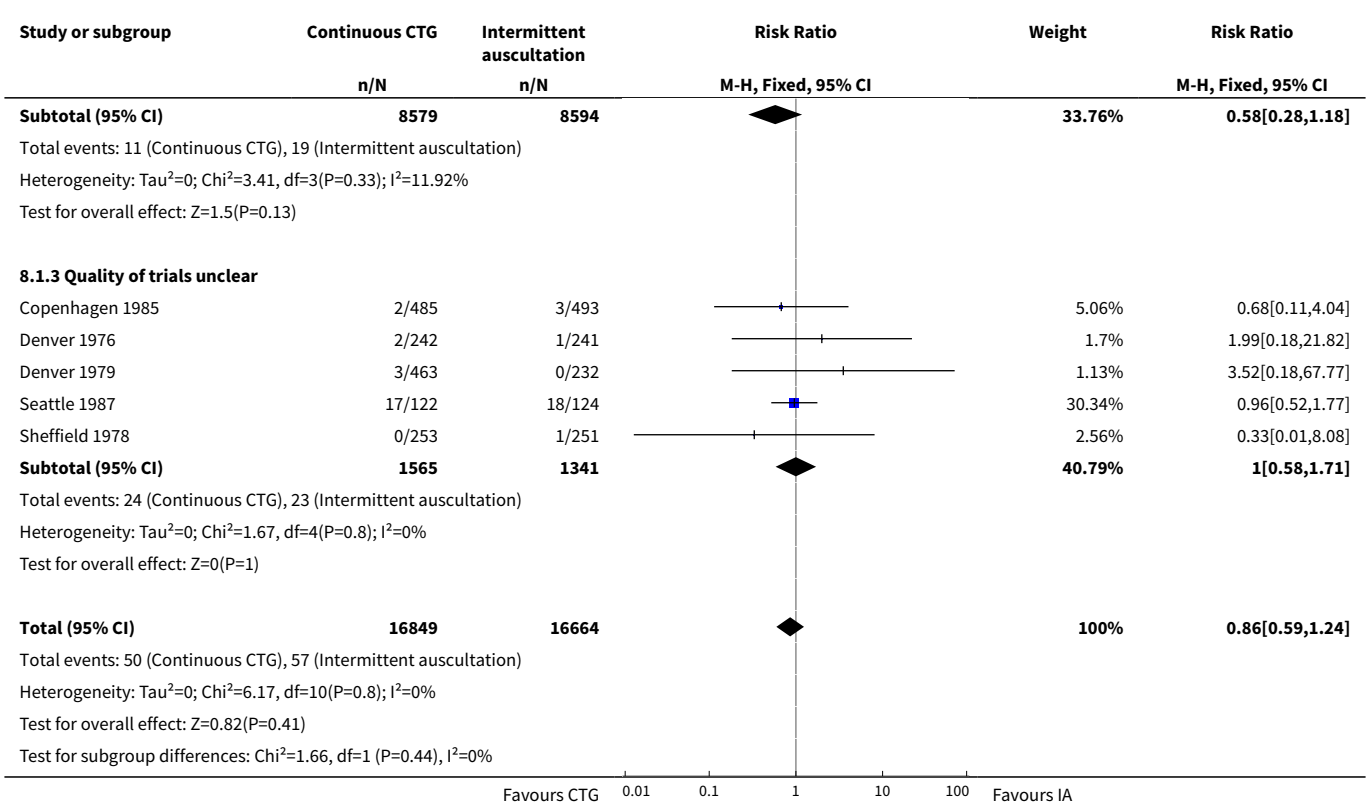
Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Perinatal mortality	11	33513	Risk Ratio (M-H, Fixed, 95% CI)	0.86 [0.59, 1.24]
1.1 High-quality trials	2	13434	Risk Ratio (M-H, Fixed, 95% CI)	1.00 [0.49, 2.05]
1.2 Low-quality trials	4	17173	Risk Ratio (M-H, Fixed, 95% CI)	0.58 [0.28, 1.18]
1.3 Quality of trials unclear	5	2906	Risk Ratio (M-H, Fixed, 95% CI)	1.00 [0.58, 1.71]
2 Neonatal seizures	9	32386	Risk Ratio (M-H, Fixed, 95% CI)	0.50 [0.31, 0.80]
2.1 High-quality trials	2	13434	Risk Ratio (M-H, Fixed, 95% CI)	0.40 [0.21, 0.77]
2.2 Low-quality trials	2	16046	Risk Ratio (M-H, Fixed, 95% CI)	0.26 [0.04, 1.60]
2.3 Quality of trials unclear	5	2906	Risk Ratio (M-H, Fixed, 95% CI)	0.83 [0.38, 1.81]
3 Cerebral palsy	2	13252	Risk Ratio (M-H, Fixed, 95% CI)	1.74 [0.97, 3.11]
3.1 High-quality trials	1	13079	Risk Ratio (M-H, Fixed, 95% CI)	1.20 [0.52, 2.79]
3.2 Low-quality trials	0	0	Risk Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]
3.3 Quality of trials unclear	1	173	Risk Ratio (M-H, Fixed, 95% CI)	2.54 [1.10, 5.86]
4 Caesarean section	11	18861	Risk Ratio (M-H, Random, 95% CI)	1.63 [1.29, 2.07]

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
4.1 High-quality trials	2	13314	Risk Ratio (M-H, Random, 95% CI)	1.27 [0.88, 1.83]
4.2 Low-quality trials	3	2555	Risk Ratio (M-H, Random, 95% CI)	1.77 [0.92, 3.41]
4.3 Quality of trials unclear	6	2992	Risk Ratio (M-H, Random, 95% CI)	1.81 [1.34, 2.44]
5 Instrumental vaginal birth	10	18615	Risk Ratio (M-H, Fixed, 95% CI)	1.21 [1.12, 1.31]
5.1 High-quality trials	2	13314	Risk Ratio (M-H, Fixed, 95% CI)	1.26 [1.13, 1.42]
5.2 Low-quality trials	3	2555	Risk Ratio (M-H, Fixed, 95% CI)	1.39 [1.17, 1.64]
5.3 Quality of trials unclear	5	2746	Risk Ratio (M-H, Fixed, 95% CI)	1.00 [0.87, 1.16]
6 Cord blood acidosis	2	2494	Risk Ratio (M-H, Fixed, 95% CI)	1.16 [0.72, 1.89]
6.1 High-quality trials	1	1075	Risk Ratio (M-H, Fixed, 95% CI)	0.45 [0.16, 1.29]
6.2 Low-quality trials	1	1419	Risk Ratio (M-H, Fixed, 95% CI)	1.58 [0.89, 2.81]
6.3 Quality of trials unclear	0	0	Risk Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]
7 Any pharmacological analgesia	3	1677	Risk Ratio (M-H, Fixed, 95% CI)	0.99 [0.93, 1.04]
7.1 High-quality trials	0	0	Risk Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]
7.2 Low-quality trials	0	0	Risk Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]
7.3 Quality of trials unclear	3	1677	Risk Ratio (M-H, Fixed, 95% CI)	0.99 [0.93, 1.04]

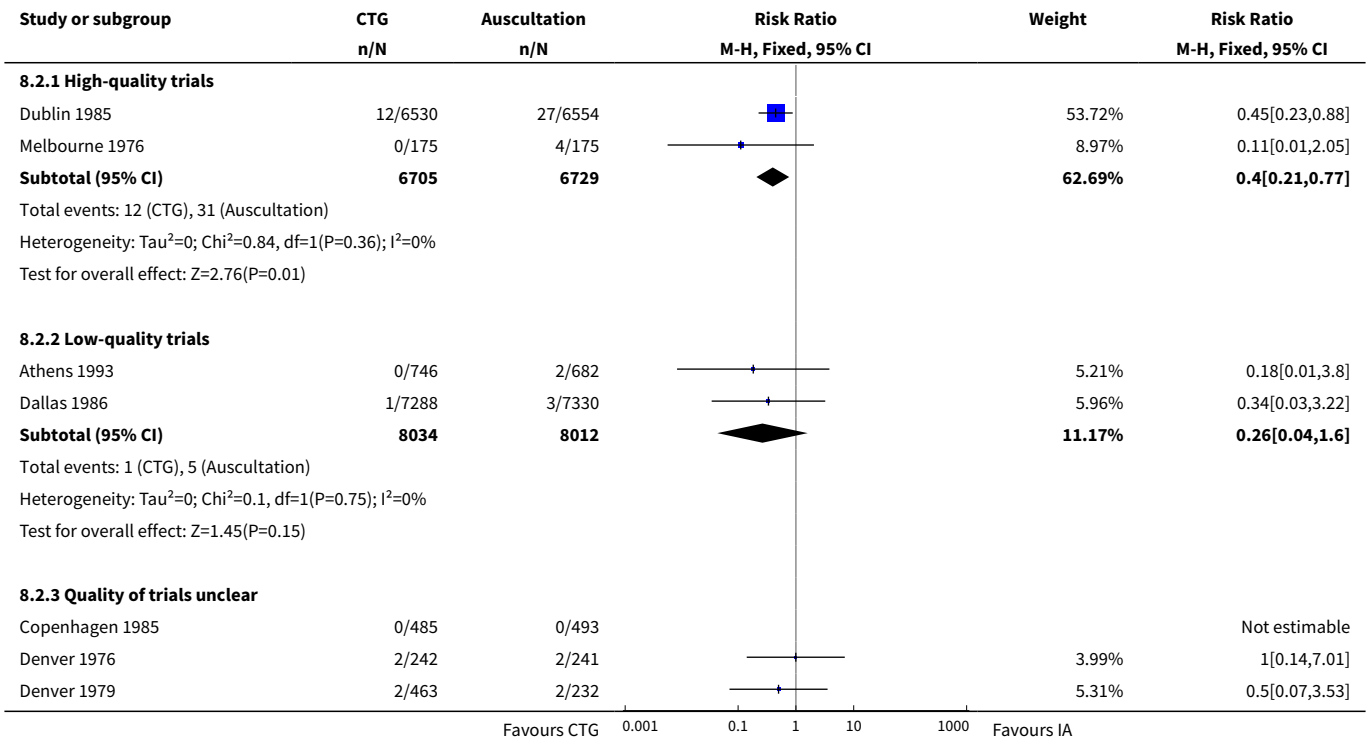
Analysis 8.1. Comparison 8 Continuous CTG versus IA (sensitivity analysis: high and low quality studies), Outcome 1 Perinatal mortality.

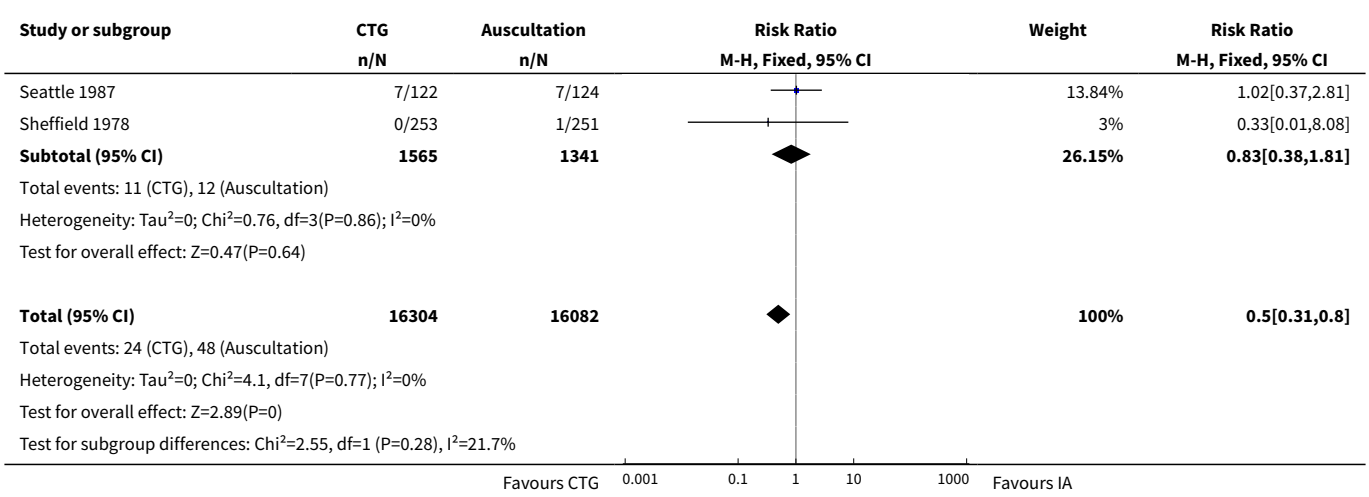
Study or subgroup	Continuous CTG n/N	Intermittent auscultation n/N	Risk Ratio M-H, Fixed, 95% CI	Weight	Risk Ratio M-H, Fixed, 95% CI
8.1.1 High-quality trials					
Dublin 1985	14/6530	14/6554		23.75%	1[0.48,2.1]
Melbourne 1976	1/175	1/175		1.7%	1[0.06,15.86]
Subtotal (95% CI)	**6705**	**6729**		**25.45%**	**1[0.49,2.05]**
Total events: 15 (Continuous CTG), 15 (Intermittent auscultation)					
Heterogeneity: Tau^2=0; Chi^2=0, df=1(P=1); I^2=0%					
Test for overall effect: Z=0.01(P=0.99)					
8.1.2 Low-quality trials					
Athens 1993	2/746	9/682		15.98%	0.2[0.04,0.94]
Dallas 1986	4/7288	5/7330		8.47%	0.8[0.22,3]
Melbourne 1981	1/445	0/482		0.82%	3.25[0.13,79.55]
Pakistan 1989	4/100	5/100		8.5%	0.8[0.22,2.89]



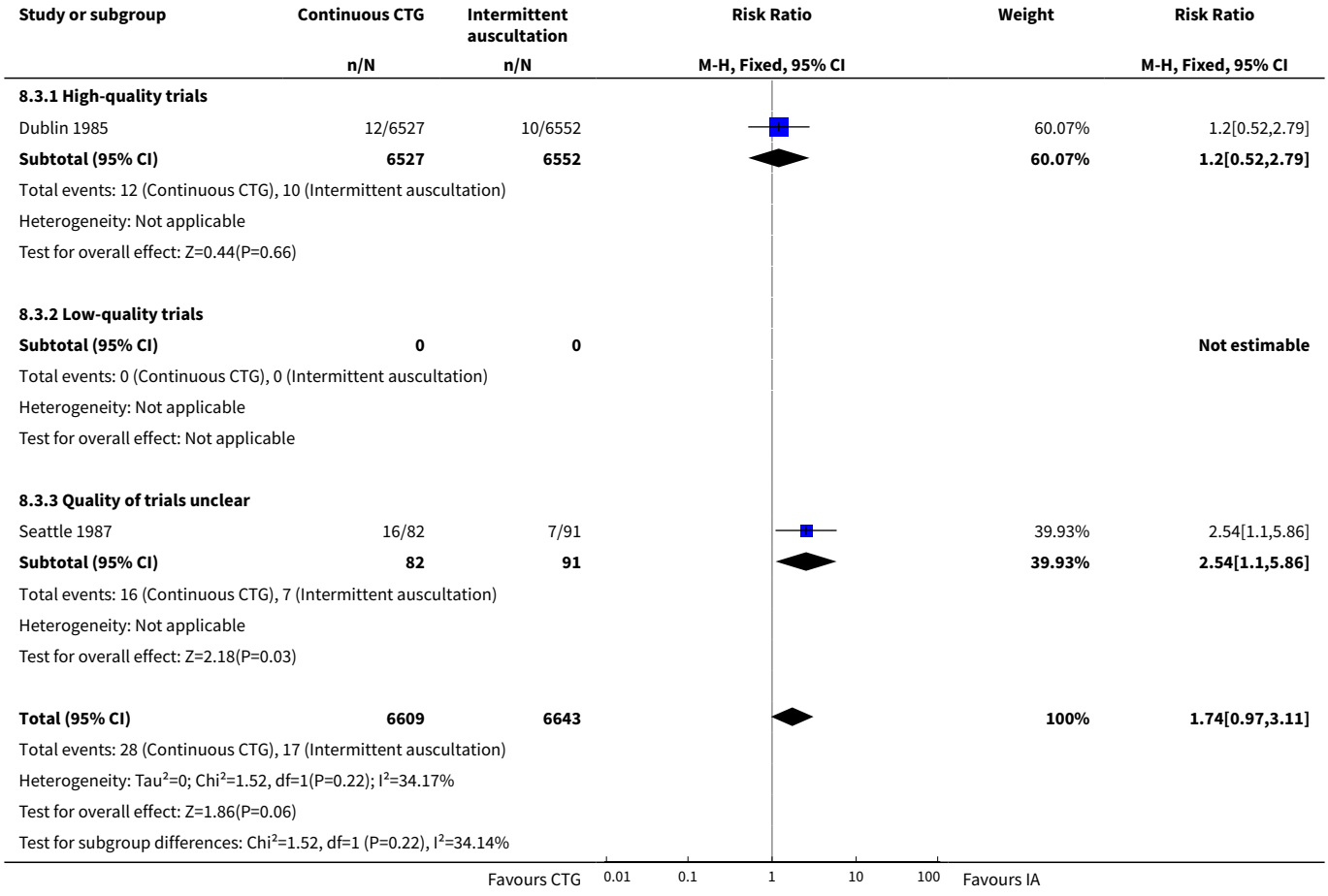


Analysis 8.2. Comparison 8 Continuous CTG versus IA (sensitivity analysis: high and low quality studies), Outcome 2 Neonatal seizures.

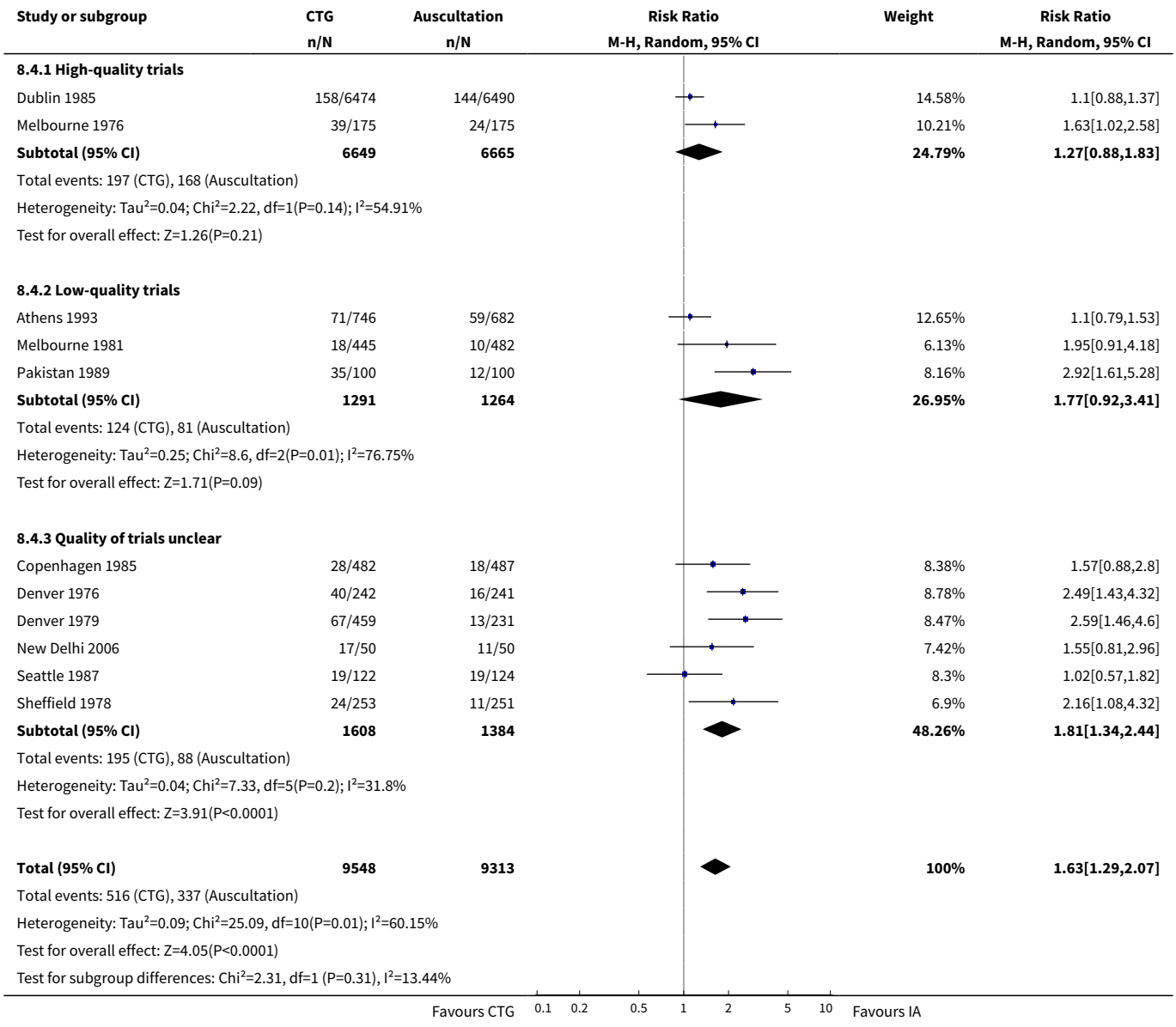




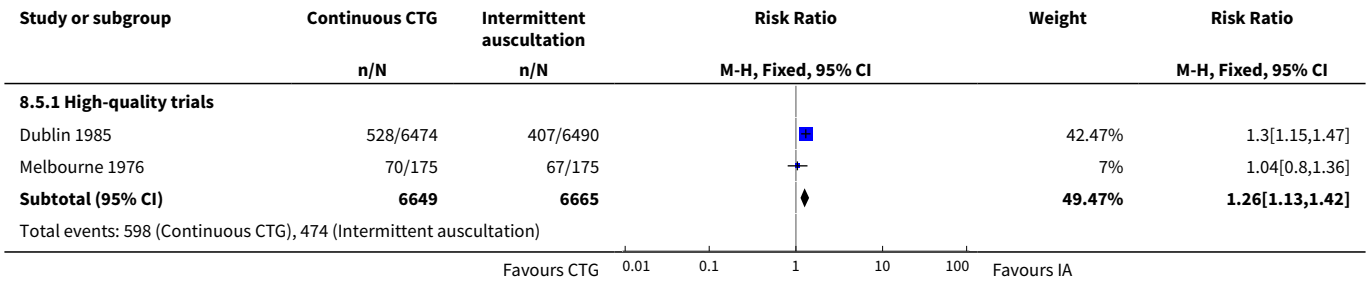
Analysis 8.3. Comparison 8 Continuous CTG versus IA (sensitivity analysis: high and low quality studies), Outcome 3 Cerebral palsy.

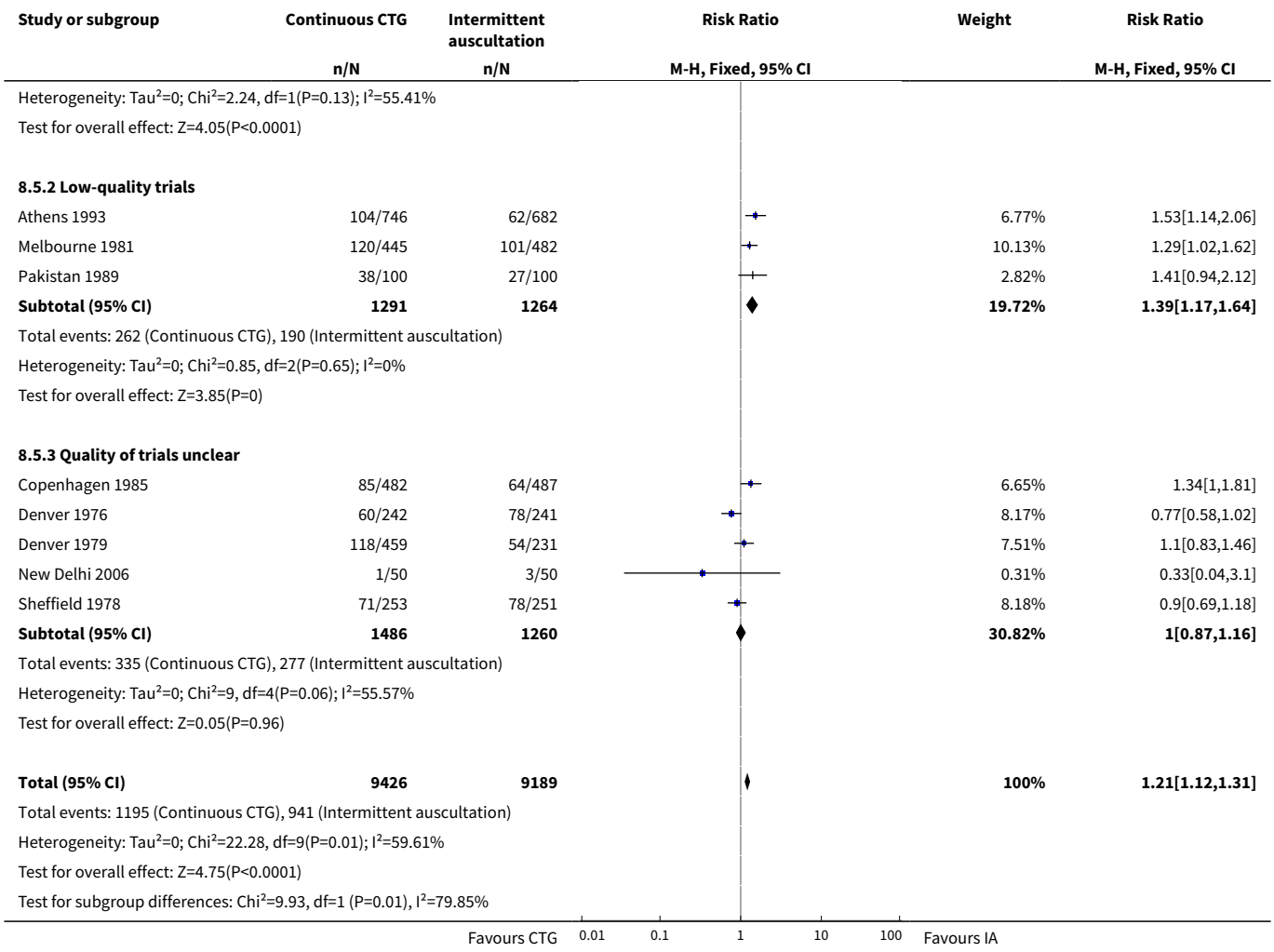


Analysis 8.4. Comparison 8 Continuous CTG versus IA (sensitivity analysis: high and low quality studies), Outcome 4 Caesarean section.

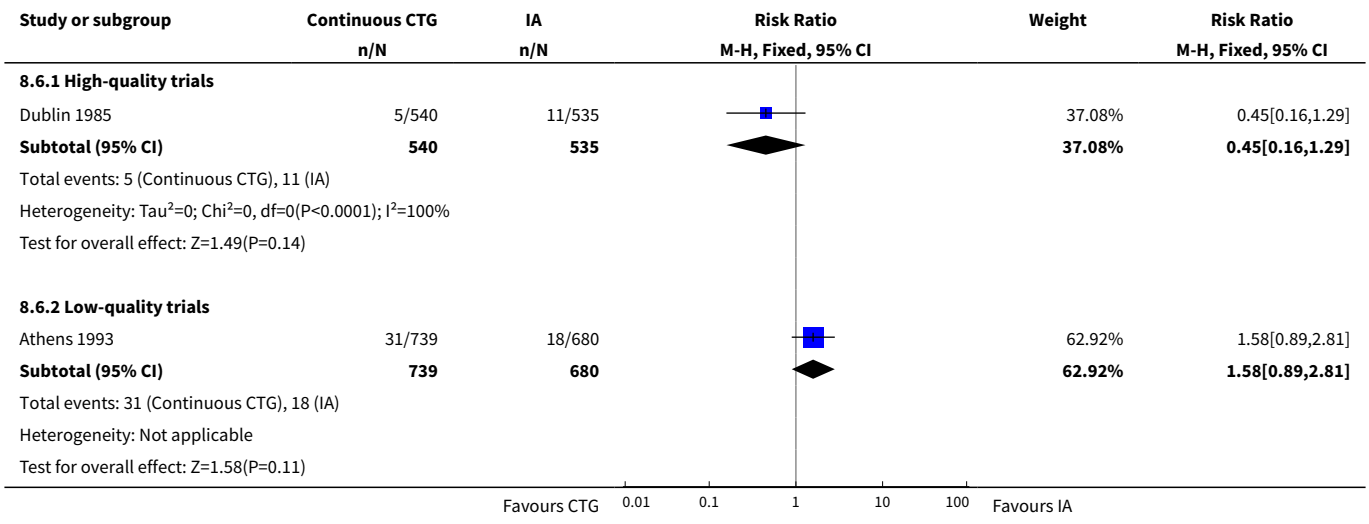


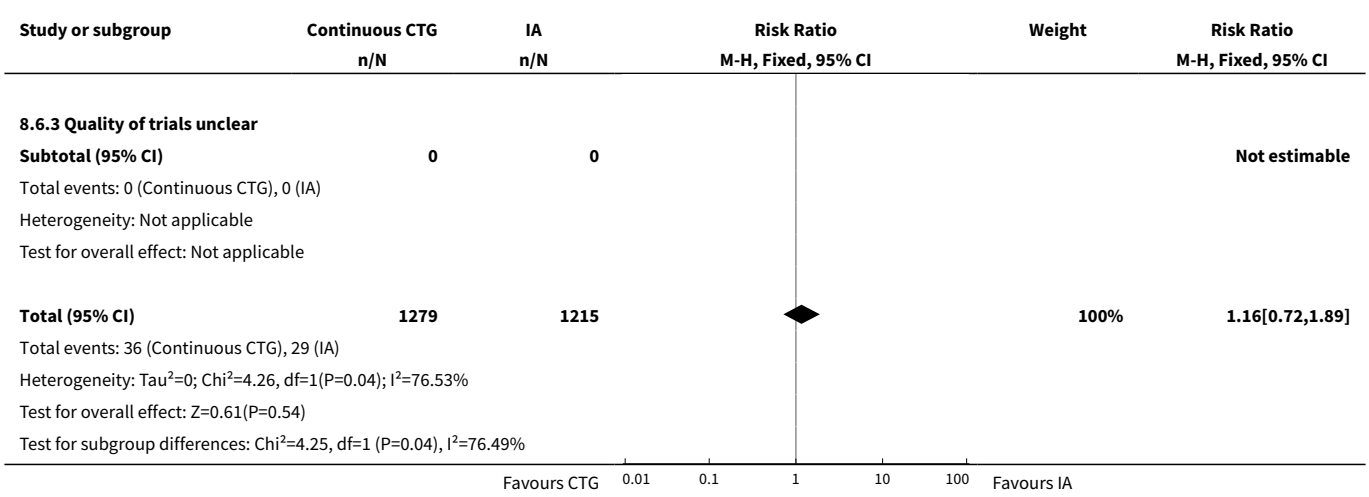
Analysis 8.5. Comparison 8 Continuous CTG versus IA (sensitivity analysis: high and low quality studies), Outcome 5 Instrumental vaginal birth.



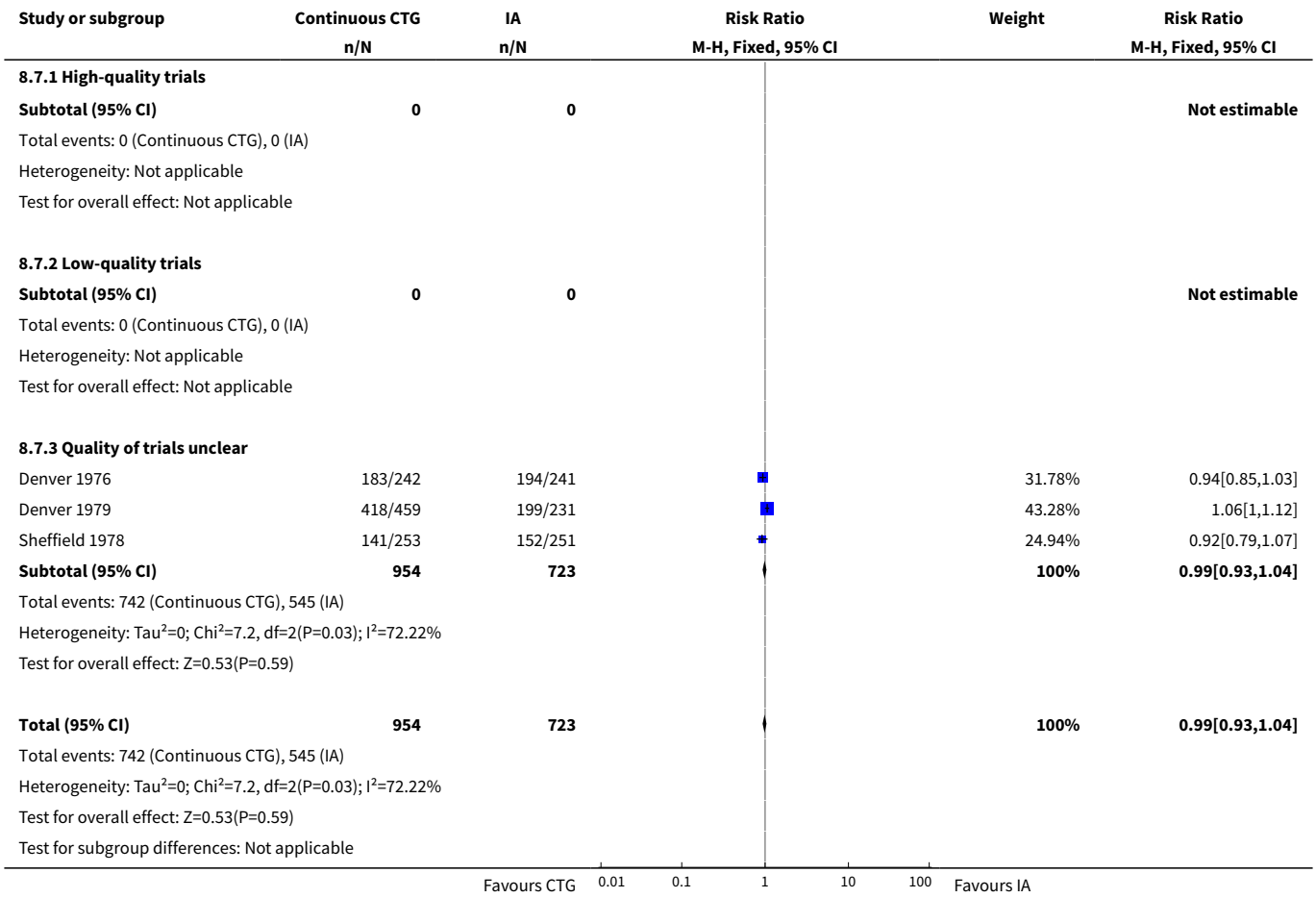


Analysis 8.6. Comparison 8 Continuous CTG versus IA (sensitivity analysis: high and low quality studies), Outcome 6 Cord blood acidosis.





Analysis 8.7. Comparison 8 Continuous CTG versus IA (sensitivity analysis: high and low quality studies), Outcome 7 Any pharmacological analgesia.



Comparison 9. Continuous CTG versus intermittent CTG

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Caesarean section (main outcome)	1	4044	Risk Ratio (M-H, Fixed, 95% CI)	1.29 [0.84, 1.97]
2 Instrumental vaginal birth (main outcome)	1	4044	Risk Ratio (M-H, Fixed, 95% CI)	1.16 [0.92, 1.46]
3 Cord blood acidosis (main outcome)	1	4044	Risk Ratio (M-H, Fixed, 95% CI)	1.43 [0.95, 2.14]
4 Apgar score < 7 at 5 minutes	1	4044	Risk Ratio (M-H, Fixed, 95% CI)	2.65 [0.70, 9.97]
5 Neonatal ICU admissions	1	4044	Risk Ratio (M-H, Fixed, 95% CI)	1.34 [0.91, 1.98]
6 Caesarean section for abnormal FHR pattern and/or acidosis	1	4044	Risk Ratio (M-H, Fixed, 95% CI)	1.19 [0.66, 2.15]
7 Spontaneous vaginal birth	1	4044	Risk Ratio (M-H, Fixed, 95% CI)	0.98 [0.96, 1.00]
8 Epidural analgesia	1	4044	Risk Ratio (M-H, Fixed, 95% CI)	1.06 [0.92, 1.21]

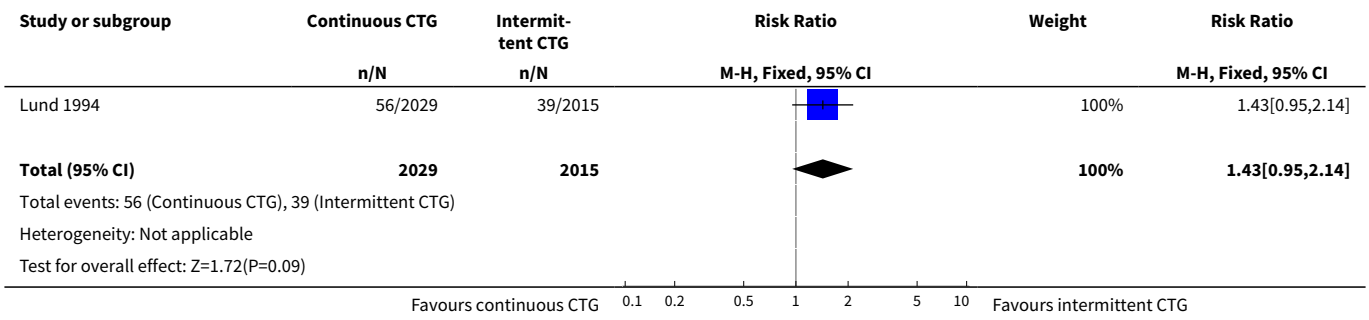
Analysis 9.1. Comparison 9 Continuous CTG versus intermittent CTG, Outcome 1 Caesarean section (main outcome).

Study or subgroup	Continuous CTG n/N	Intermittent CTG n/N	Risk Ratio M-H, Fixed, 95% CI	Weight	Risk Ratio M-H, Fixed, 95% CI
Lund 1994	48/2029	37/2015		100%	1.29[0.84,1.97]
Total (95% CI)	**2029**	**2015**		**100%**	**1.29[0.84,1.97]**
Total events: 48 (Continuous CTG), 37 (Intermittent CTG)					
Heterogeneity: Not applicable					
Test for overall effect: Z=1.17(P=0.24)					

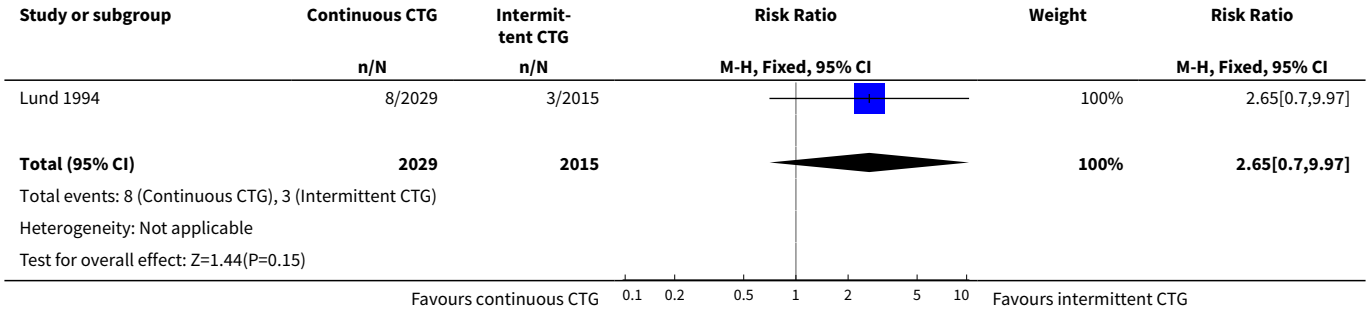
Analysis 9.2. Comparison 9 Continuous CTG versus intermittent CTG, Outcome 2 Instrumental vaginal birth (main outcome).

Study or subgroup	Continuous CTG n/N	Intermittent CTG n/N	Risk Ratio M-H, Fixed, 95% CI	Weight	Risk Ratio M-H, Fixed, 95% CI
Lund 1994	148/2029	127/2015		100%	1.16[0.92,1.46]
Total (95% CI)	**2029**	**2015**		**100%**	**1.16[0.92,1.46]**
Total events: 148 (Continuous CTG), 127 (Intermittent CTG)					
Heterogeneity: Not applicable					
Test for overall effect: Z=1.25(P=0.21)					

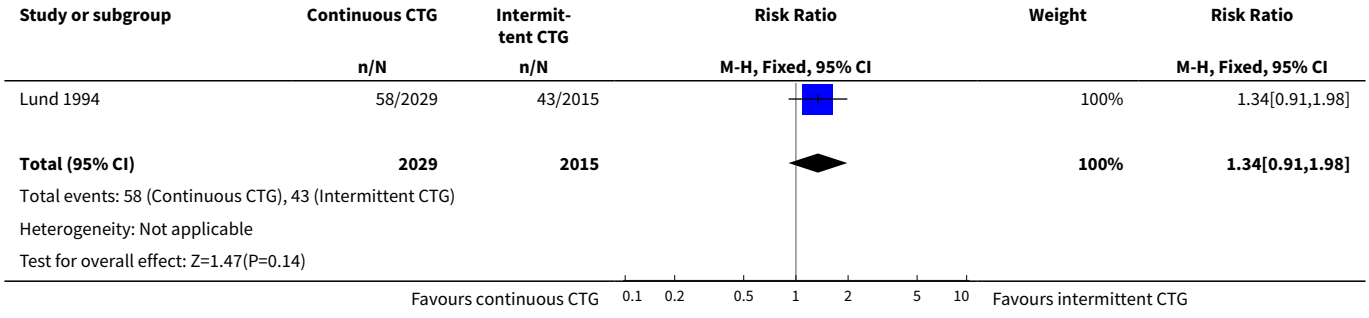
Analysis 9.3. Comparison 9 Continuous CTG versus intermittent CTG, Outcome 3 Cord blood acidosis (main outcome).



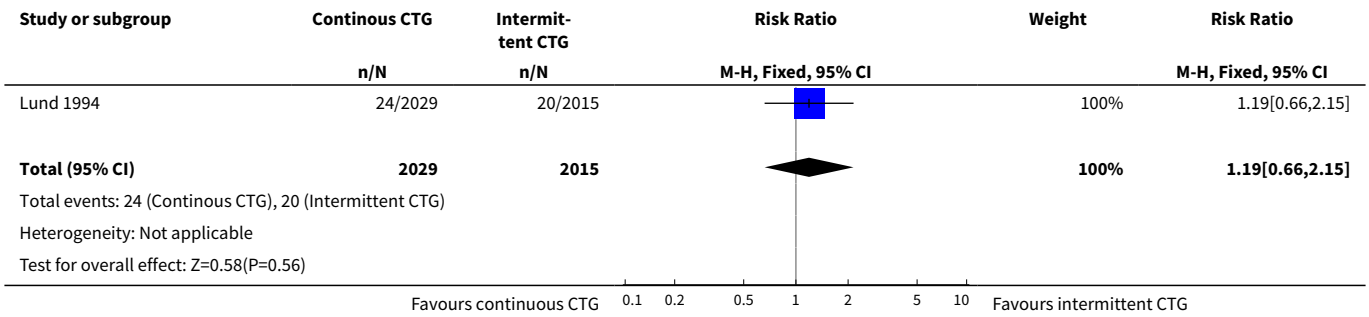
Analysis 9.4. Comparison 9 Continuous CTG versus intermittent CTG, Outcome 4 Apgar score < 7 at 5 minutes.



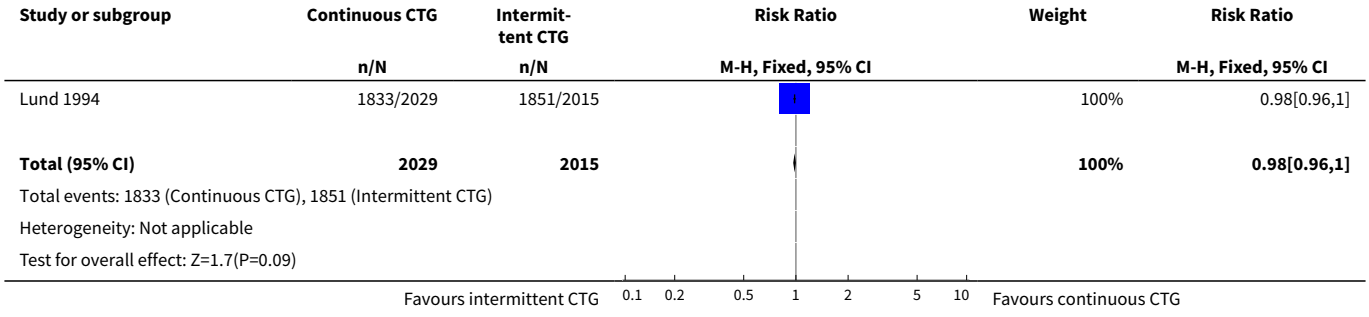
Analysis 9.5. Comparison 9 Continuous CTG versus intermittent CTG, Outcome 5 Neonatal ICU admissions.



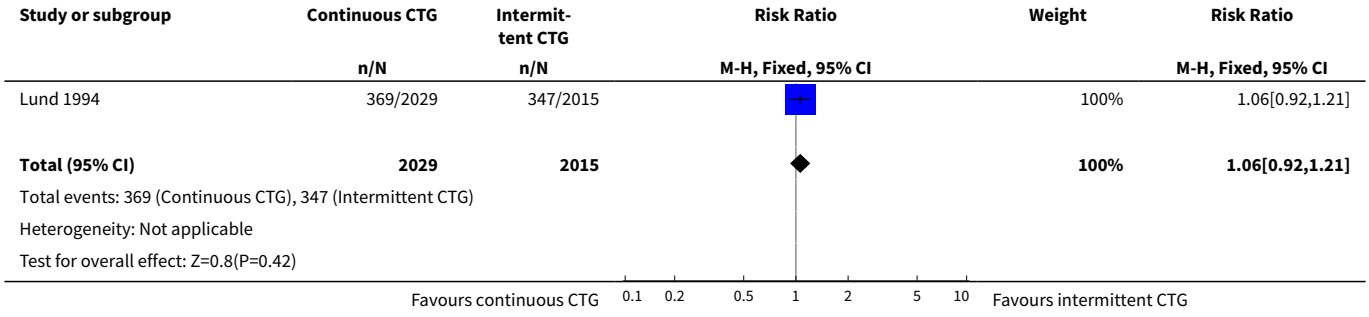
Analysis 9.6. Comparison 9 Continuous CTG versus intermittent CTG, Outcome 6 Caesarean section for abnormal FHR pattern and/or acidosis.



Analysis 9.7. Comparison 9 Continuous CTG versus intermittent CTG, Outcome 7 Spontaneous vaginal birth.



Analysis 9.8. Comparison 9 Continuous CTG versus intermittent CTG, Outcome 8 Epidural analgesia.



ADDITIONAL TABLES

Table 1. Methods of fetal heart rate monitoring

Method	Description
Fetal stethoscope (Pinard) - for intermittent monitoring (IA)	This is a trumpet-shaped device, which is placed on the mother's abdomen and the caregiver listens for the heart beat at the other end. This is a simple instrument of relatively low cost

Table 1. Methods of fetal heart rate monitoring *(Continued)*

Hand-held Doppler ultrasound monitor - for intermittent monitoring (IA)	The device is placed on the mother's abdomen with gel smeared on the underside of the ultrasound transducer. This allows the ultrasound beam to travel from the fetal heart to the transducer without interruption
External cardiotocography - for continuous or intermittent monitoring	The fetal heart rate and the activity of the uterine muscle are detected by two transducers placed on the mother's abdomen (one above the fetal heart and the other at the fundus). Doppler ultrasound provides the information which is recorded on a paper strip known as a cardiotocograph (CTG).
Internal cardiotocography - for continuous monitoring	An electrode is placed directly on the baby's presenting part to detect the fetal ECG signal. Again the signals are recorded on a paper strip (CTG). This method can only be used if membranes (forewaters) have ruptured either spontaneously or artificially

ECG: electrocardiogram
IA: intermittent auscultation

Table 2. Additional descriptive information from included studies

Study	1 carer to 1 woman	Induction	ARM	Oxytocin	Mobility	Birth positions	Women's views	Social context	Experience of staff
Athens 1993	Yes	Induction - 11% overall	No information	Augmentation - 46% overall	No mobility - all women with IV line inserted	Semi-Fowler or lateral	No information	No information	IA standard practice, EFM intensive training provided
Copenhagen 1985	No information	No information	No information	No information	EFM only applied when women no longer wished to walk around	No information	No information	No information	No information
Dallas 1986	2 women: 1 nurse	Excluded women whose labours were induced	No information	Excluded women	No information	No information	No information	No information	No information
Denver 1976	IA: yes CTG: no information	Included women whose labours were induced	No information	Included women given oxytocin for augmentation	No information	No information	No information	No information	No information
Denver 1979	Yes	No specific information	No information	29% of women given oxytocin for augmentation	No information	No information	No information	No information	No information
Dublin 1985	Yes	Included women whose labours were induced	ARM within an hour of admission to check liquor	23% of women given oxytocin for augmentation	IA, probably more mobile	No information	Women's views sought and published separately	No information	No information
Lund 1994	No information	Included women whose labours were induced	No information	48% of women were given ocytocin for induction or acceleration	Women in CTG group offered telemetry if wished mobility	No information	No information	No information	No information
Melbourne 1976	No information	Induction - 42% overall	No information	63% of women given oxytocin in labour	No information	No information	No information	No information	Exp staff.

Table 2. Additional descriptive information from included studies *(Continued)*

Melbourne 1981	No information	No information	ARM when in established labour or for obstetric reasons	No information	No information	No information	No information	No information	No information
Pakistan 1989	No information	No information	No information	No information	No information	No information	No information	No information	No information
New Delhi 2006	No information	No information	No information	No information	No information	No information	No information	No information	No information
Seattle 1987	Yes	No information	ARM at 7 cm unless clinically indicated prior to 7 cm	Included women given oxytocin	No information	No information	Women's views sought and published separately.	No information	No information
Sheffield 1978	No information	Included women whose labours were induced	Augmentation with ARM alone or in combination with oxytocin if progress fell below nomogram	Oxytocin was administered to all women as indicated	No information	No information	No information	No information	No information

ARM: artificial rupture of membranes
CTG: cardiotocography
EFM: electronic fetal monitoring
IA: intermittent auscultation
IV: intravenous

Table 3. Intermittent auscultation methods - additional information from included studies

Study	Intermittent auscultation details			Additional details					
	Method	Frequency first and second stages	Before / during / following contraction; Duration	ARM	Oxytocin	FBS	Admission CTG	Risk level	1 carer to 1 woman
Athens 1993	Sonicaid	First stage: At least every 15 minutes	During and following.	No information	Augmentation - 46% overall	No	No information	High and low risk	Yes

Table 3. Intermittent auscultation methods - additional information from included studies *(Continued)*

		Second stage: Every 5 minutes	Duration: For 1 min including at least 30 seconds after the contraction						
Copenhagen 1985	No information	First stage: At least 15 s twice an hour up to 5 cm. Above 5 cm every 15 minutes Second stage: After every contraction	Following. Duration: 30 seconds	No information	No information	No information	No information	High and low risk	No information
Dallas 1986	Hand-held device	First stage: Every 30 minutes Second stage: No information	No information	No information	Excluded women given oxytocin for augmentation	No information	No information	Low and high risk	2 women: 1 nurse
Denver 1976	No information	First stage: Every 15 minutes Second stage: every 5 minutes	Following. Duration: 30 seconds	No information	Included women given oxytocin for augmentation	No information	No information	High risk	IA: yes CTG: no information
Denver 1979	No information	First stage: Every 15 minutes Second stage: every 5 minutes	Following. Duration: 30 seconds	No information	29% of women given oxytocin for augmentation	No	No information	High risk	Yes
Dublin 1985	Pinard unless difficult then used Doppler ultrasound	First stage: Every 15 minutes Second stage: Every interval between contractions	Following. Duration: 1 minute	ARM within an hour of admission to check liquor	23% of women given oxytocin for augmentation	When labour > 8 hours. CTG: 77/6474 (1.2%) IA: 139/6486 (2.1%)	No information	No information	Yes
Lund 1994	Continuous monitoring if oxytocin or epidural used. Back to IA if stable. If FHR	First stage: 15 to 30 minutes Second stage: Continuous CTG	No information	No information	48% of women were given oxytocin for induction or acceleration	No information	No information	Low-moderate risk	No information

Table 3. Intermittent auscultation methods - additional information from included studies *(Continued)*

	changes appeared, or if there were other complications,continuous monitoring was instituted								
Melbourne 1976	No information	First stage: Intermittent Second stage: No information	None	No information	63% of women given oxytocin in labour	No	No information	High risk women only	No information
Melbourne 1981	No information	First stage: Intermittent Second stage: No information	None	ARM when in established labour or for obstetric reasons	No information	No	No information	Low risk	No information
Pakistan 1989	Pinard	First stage: Every 15 minutes Second stage: No information	No information	No information	No information	No as a matter of policy	No information	All had meconium during labour	No information
New Delhi 2006	No information	First stage: Every 15 minutes Second stage: Every 5 minutes	Following. Duration: 1 minute	No information	No information	No information - appears not, as any unreassuring FHR went straight to CS or forceps	No information	All post-caesarean women	No information
Seattle 1987	No information	First stage: Every 15 minutes Second stage: Every 5 minutes	No information	ARM at 7 cm unless clinically indicated prior to 7 cm	Included women given oxytocin	No	No information	Low birthweight fetus 26 to 32 weeks gestation	Yes

Table 3. Intermittent auscultation methods - additional information from included studies *(Continued)*

Sheffield 1978	Pinard (if any difficulty a Sonicaid was used intermittently)	First stage: Every 15 minutes or more if indicated Second stage: No information	During or immediately following contraction. Duration: 1 minute	Augmentationwith ARM alone or in combination with oxytocin if progress fell below nomogram	Oxytocin was administered to all women as indicated	No information	No information	Low risk women only	No information

ARM: artificial rupture of membranes
CTG: cardiotocography
EFM: electronic fetal monitoring
FBS: fetal blood sampling
FHR: fetal heart rate
IA: intermittent auscultation

FEEDBACK

Ingemarsson, 30 March 2008

Summary

In this review you comment on the significant reduction in neonatal seizures associated with continuous cardiotocography rather than intermittent auscultation, but then put this in opposition to the increase in caesarean section. Yet, more caesarean sections are performed without clinical indication, on maternal `request' than are performed for threatening fetal hypoxia. Moreover, you stress that continuous cardiotocography is not associated with any beneficial effect on the risk of cerebral palsy, because 80%-85% of cases have an antenatal origin and therefore intrapartum CTG can not be expected to have a great impact on the overall figure.

A recent Swedish study (Lindström 2006) reported outcome at 15-19 years of age after moderate hypoxic-ischaemic encephalopathy (Sarnat II with neonatal seizures in most cases). Of 43 children with moderate hypoxic-ischaemic encephalopathy, 15 had cerebral palsy. Of the 28 children without encephalopathy, 20 had cognitive problems. Only 8 of the 43 children had no problem later in life. So, a halving in neonatal seizures with continuous cardiotocography seems to me, as an old obstetrician, to be a very good outcome.

(Summary of feedback from Ingemar Ingemarsson, March 2008)

Reply

Thank you for your comments. In our review, we feel we have clearly articulated the perceived conflict between our findings of increased caesarean section and instrumental vaginal birth and decreased incidence of neonatal seizures associated with continuous CTG when compared with intermittent auscultation.

We are unaware of any high quality evidence that demonstrates a higher rate of caesarean sections due to maternal ‘request’ than due to hypoxia. Caesarean sections for maternal ‘request’ is a complex issue and there are those who have argued that it is not a significant influencing factor on caesarean rates (Gamble 2007) Even if such evidence existed, we believe that this is addressing a different question from that in our review.

The focus of the quoted study by Lindström et al (Lindström 2006) is on neonatal encephalopathy. In our review, we highlighted that much remains to be learned about the causation and possible links between antenatal or intrapartum events, neonatal seizures and long-term neurodevelopmental outcome. For this reason we believe it reasonable to base clinical decisions on the evidence we currently have.

Contributors

Zarko Alfirevic
Declan Devane
Gillian Gyte

Panteghini, 30 September 2013

Summary

I have two comments about this review:

1) In the continuously monitored group the relative risk of perinatal mortality is lower rather than in the intermittently monitored group (RR 0.86). This result may be important for women when they choose which method of fetal monitoring to adopt during labour. Is it not more useful to present the absolute and relative risk, so the woman, her midwife and doctor can decide if these are significant to them or not? To consider a result significant only if it is statistically significant (and only if statistically significant at a given level of significance, such as 5%) is an arbitrary decision that needs to be shared with the woman and her clinical team.

2) An interesting question raised by this review is which method of intermittent auscultation is best. The review lumps together different types of intermittent auscultation; for example, auscultation during and after a contraction, and auscultation only after a contraction.

The review assesses the relationship between pH at birth and the method of foetal heart monitoring rate (intermittent or continuous) in two studies (Athens 1993; Dublin 1985), and does not find any difference between the two methods as regards neonatal pH at birth. It is interesting to note that in the Dublin trial, which used intermittent auscultation only after a contraction, the pH at birth was worse for woman allocated intermittent auscultation rather than continuous monitoring (RR 0.45, 95% CI 0.16 - 1.29). In contrast, in the Athens trial, which used intermittent auscultation during and after the contraction, pH at birth was better for woman allocated intermittent auscultation (RR 1.58, 95% CI 0.89 - 2.81).

The importance of decelerations during the contraction and their impact on foetal wellbeing is now well known. Therefore the National Institute for Clinical Excellence (NICE) (1) considers monitoring to be reassuring only if there are no decelerations. Some guidelines advise monitoring the foetal heart after a contraction (2), others during and after (3), and others again do not specify the timing of auscultation in relation to contraction (4). The review is appropriate in not drawing any conclusions about what is the best method of intermittent monitoring. We think that guidelines should state both that the mode of intermittent monitoring and the choice of one method rather

than another is a grade C recommendation (personal opinion) (5) as, in the light of this review, we do not know which method of intermittent monitoring is best (although we could suppose that intermittent auscultation during and after a contraction may be better than auscultation only after a contraction for preventing low pH at birth).

References

(1) NICE. Intrapartum care, 2008; p219-220 Tables 13.1, 13.2.

(2) Royal College of Midwives. Evidence based guidelines for midwifery-led care in labour,2012.

(3) American College of Nurse and Midwives. Intermittent Auscultation for Intrapartum Fetal Heart Rate Surveillance. Journal of Midwifery and Women's Health, 2010; 55: 397-403.

(4) Association of Women's Health Obstetric and Neonatal Nurses. Fetal Heart Monitoring, 2008

(5) Danti L, Di Tommaso MR, Maffetti G, Carfagna M. Cardiotocografia. Milano 2010, Piccin editore.

Comment submitted by Marco Panteghini, September 2013

Reply

1) We agree that the concept of statistical significance arbitrary and therefore needs to be shared with the woman and her clinical team as such. However, focusing on point estimates of relative or absolute risk reduction is not a solution. Whilst it is correct that the relative risk for perinatal mortality is 0.86, the 95% confidence intervals suggests that use of cardiotocography is compatible with much higher risk reduction (41%), but also with an increase in perinatal mortality (up to 23%). For this reason, we concluded that the observed difference in perinatal death is not significant, both clinical and statistical terms.

2) We agree that the issue of generaliziblity (external validity) of the data from this review is important not just for cardiotocography, but also for intermittent auscultation (IA). The protocols for IA, training and monitoring of adherence varied considerably in the studies and in clinical practice world wide, We have added Table 3 to highlight this issue and discussed further in the section Overall completeness and applicability of evidence.

Contributors

Zarko Alfirevic
Declan Devane
Gillian Gyte

WHAT'S NEW

Date	Event	Description
10 May 2019	Amended	Edited Declarations of interest

HISTORY

Protocol first published: Issue 3, 2006
Review first published: Issue 3, 2006

Date	Event	Description
20 March 2017	Amended	Minor edits to the text and table to clarify that Sheffield 1978 study participants were at low risk of complications. We have made edits to the Included studies section and the Characteristics of included studies table for Sheffield 1978.
30 November 2016	Feedback has been incorporated	The review authors have added a response to Feedback 2.
30 November 2016	New search has been performed	Search updated - no new studies identified.

Date	Event	Description
30 November 2016	New citation required but conclusions have not changed	We have now incorporated updated methods including the use of GRADE to assess the quality of the evidence and inclusion of a summary of findings table. We have restructured the plain language summary to incorporate standardised headings. We have change 'primary outcomes' to 'main outcomes' and 'secondary outcomes' to 'other important outcomes'. The discussion has been updated in response to Feedback 2.
30 September 2013	Feedback has been incorporated	Feedback 2 received from Marco Panteghini.
31 December 2012	New search has been performed	Search updated. Two trial reports identified. One new study has been included (New Delhi 2006) and one is awaiting classification (Greece 2012). This review is now comprised of 13 included studies (involving over 37,000 women) and four excluded studies.
31 December 2012	New citation required but conclusions have not changed	The inclusion of one new study has not changed the results and conclusions of this review.
23 July 2008	Amended	Converted to new review format.
23 July 2008	Feedback has been incorporated	Feedback added with reply from authors.

CONTRIBUTIONS OF AUTHORS

Zarko Alfirevic (ZA) drafted the protocol. Declan Devane (DD) and Gill Gyte (GG) commented on all sections.
ZA and GG assessed studies in respect of inclusion and exclusion criteria.

DD ran additional searches. ZA and DD extracted the data independently and double entered them into Review Manager. GG extracted additional descriptive information from included studies. All authors wrote and agreed the final version of the review.

For the 2016 update, ZA and DD provided comments for feedback and discussion. GG wrote the Plain Language Summary. Anna Cuthbert prepared the update and all authors commented on and agreed the final version.

DECLARATIONS OF INTEREST

Zarko Alfirevic (ZA) is Director of Harris Wellbeing Preterm Birth Centre which is grant funded by the charity Wellbeing of Women. This grant is administered by University of Liverpool and Zarko Alfirevic is not paid directly. He is the principal investigator or co-investigator on several grants from public funders including National Institute of Health Research, British Medical Association, European Commission and WHO. He has received research support in the past from Perkin Elmer and Alere for research related to pre-eclampsia and preterm birth prevention. These grants were administered by his employers and ZA did not benefit directly. ZA is also a Co-coordinating Editor of Cochrane Pregnancy and Childbirth.

Declan Devane has conducted a trial, known as the ADCAR Trial, evaluating the effectiveness of the admission cardiotocograph (CTG) compared with intermittent auscultation. This study is funded by the Health Research Board (Ireland). If this trial is eligible for inclusion in the full review, or a subsequent review update, the investigators will not be involved in assessing the trial for inclusion, assessing risk of bias, or data extraction. These tasks will be carried out by two other members of the review team who are not directly involved with the ADCAR Trial.

Gillian ML Gyte has received royalties from John Wiley & Son in respect of 'A Cochrane Pocket Handbook – Pregnancy and Childbirth' Hofmeyr GJ et al. 2008.

Anna Cuthbert: I am a research associate working in the editorial base of Cochrane Pregnancy and Childbirth. I am employed by the University of Liverpool to work as a research assistant in Cochrane Pregnancy and Childbirth (who receives infrastructure funding from the NIHR, UK).

SOURCES OF SUPPORT

Internal sources

- No sources of support supplied

External sources

- UNDP-UNFPA-UNICEF-WHO-World Bank Special Programme of Research, Development and Research Training in Human Reproduction (HRP), Department of Reproductive Health and Research (RHR), World Health Organization, Switzerland.

DIFFERENCES BETWEEN PROTOCOL AND REVIEW

We incorporated updated methods including the use of GRADE to assess the quality of the evidence and inclusion of Summary of findings for the main comparison as recommended by Cochrane's MECIR standards.

We restructured the plain language summary to incorporate standardised headings in line with Cochrane Pregnancy and Childbirth policy.

We changed 'primary outcomes' to 'main outcomes' and 'secondary outcomes' to 'other important outcomes'. We felt these terms were appropriate for both 'plain language' and to avoid any confusion with primary outcomes used in trials.

We used interaction tests to further explore the effect of quality of trials on the analyses.

INDEX TERMS

Medical Subject Headings (MeSH)

*Labor, Obstetric; Cardiotocography [*methods]; Cesarean Section [statistics & numerical data]; Heart Auscultation [*methods]; Heart Rate, Fetal [physiology]; Infant Mortality; Randomized Controlled Trials as Topic; Seizures [prevention & control]

MeSH check words

Female; Humans; Infant; Infant, Newborn; Pregnancy